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Institution of municipal &
= county engineers, fnd.

PROCEEDINGS

OF THE

INCORPORATED ASSOCIATION OF MUNICIPAL AND COUNTY ENGINEERS

VOLUME XXVI. 1899-1900

EDITED BY

THOMAS COLE

ASSOC. M. INST. C.E.

(*Secretary of the Association*)

The Association is not as a body responsible for the facts and opinions advanced herein.

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*Parr, N.	Surveyor to the Urban District Council, Brentford.
*Parr, F. H.	Surveyor to Urban District Council, Wealdstone.
Paton, J. (*Member of Council.*)	Borough Engineer, Plymouth.
Pattison, W. P.	Surveyor to the Urban District Council, Benwell and Fenham.
Peacock, T. J.	Surveyor to the Rural District Council, Spalding.
Pearce, F. W.	Surveyor to Urban District Council, Twickenham.
Pearson, W. T.	Surveyor to the Urban District Council, Rothwell, Northants.
Pease, C. R.	Borough Surveyor, Todmorden.
Peet, H. F.	City Engineer, Bloemfontein, South Africa.
Peirce, R., Assoc.M.Inst.C.E.	Municipal Engineer, Penang, Straits Settlements.
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*Pickles, G. H., A.M.Inst.C.E.	Borough Surveyor, Burnley.
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Pratt, R.	Borough Surveyor, Henley-on-Thames.
Prescott, A. E.	Borough Surveyor, Douglas, Isle of Man.
Prescott, W. H.	Surveyor to Urban District Council, Tottenham.
Press, W. J.	Surveyor to the Urban District Council, Burnham, Somerset.
*Price, A. J.	Surveyor to the Urban District Council, Lytham.
Price, J., M. Inst. C.E. (*Member of Council.*)	City Surveyor, Birmingham.
Priestley, C. H.	Corporation Water Engineer, Cardiff.
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Proffitt, J. T.	Surveyor to the Urban District Council, Worsley, Walkden, Bolton.
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Pullar, W. M.	Shire Engineer, Coburg, Victoria.
Purnell, E. J.	Water Engineer, Coventry, Warwickshire.
Purser, W. B.	County Surveyor, West Sussex. Horsham.
*Putman, W. E., A. M. Inst. C.E.	Borough Surveyor, Morley.
Pym-Jones, I.	Borough Surveyor, Lymington.
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Rayner, F. J.	Surveyor to Urban District Council, Newhaven.
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Richardson, J.	Surveyor to Urban District Council, Stamford.
Richardson, R.	Surveyor to the Urban District Council, Malton.
Ridout, A. R.	Surveyor to the Urban District Council, Stone.
Roberts, D.	Borough Surveyor, Lewes.
*Roberts, F., A. M. Inst.C.E.	Borough Engineer, Worthing.
Robinson, A. R.	Surveyor to Urban District Council, Clacton-on-Sea.
Robinson, W. P.	Surveyor to the Urban District Council, Skelton-in-Cleveland.
Robinson, W. J.	City Surveyor, Londonderry.

ROBSON, O. C., M. Inst. C.E. (*Past President.*)	Surveyor to the Urban District Council, Willesden, Middlesex.
RODWELL, A.	Surveyor to the Rural District Council, Skipton.
ROGERS, W. E.	Surveyor to the Urban District Council, Rugely.
ROSS, John C., A.M. Inst. C.E.	Town Engineer, Warrnambool, Victoria, Australia.
ROSS, P., Assoc. M. Inst. C.E.	Surveyor to the Urban District Council, North Bierley, Bradford.
ROTHERA, F. B.	Surveyor to the Urban District Council, Biggleswade.
ROUNTHWAITE, R. S., Assoc. M. Inst. C.E.	City Engineer, Wellington, New Zealand.
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RUCK, F. W.	County Surveyor, Kent. Maidstone.
RUSHBROOKE, T. J.	Borough Surveyor, High Wycombe.
*RUSHTON, E	Surveyor to the Urban District Council, Cleethorpes.
SADLER, G. W.	467 High Street, Cheltenham.
*SAISE, A. J., Assoc. M. Inst. C.E.	Surveyor, Stapleton, Bristol.
SALKIELD, T.	Surveyor to Urban District Council, Hoddesdon.
SASSE, G. H.	Borough Surveyor, Chelmsford.
*SAUNDERS, J.	City Surveyor, Chichester.
SAVAGE, W. H., A.M.Inst.C.E.	"Montfichet," East Ham.
SAVILLE, J.	Town Surveyor, Heckmondwike.
SCHOFIELD, W. H., ...	County Surveyor. Lancashire.
SCORGIE, N., A.M. Inst. C.E.	Vestry Surveyor, Hackney.
SCOTT, A. F.	Surveyor to the Urban District Council, Cromer.
SCOTT, H. H., A.M.Inst.C.E.	Engineer to the Commissioners, Hove.
SCOTT, R. S., Assoc. M. Inst. C.E.	Surveyor to the Urban District Council, Bishop's Stortford.
SCOTT, T.	Surveyor to Rural District Council, Tadcaster.
SENIOR, C. E...	Surveyor to Urban District Council, Upholland.
SENIOR, J. S.	Surveyor to the Urban District Council, Swanage.
*SETTLE, J. A., A.M.Inst.C.E.	Borough Engineer and Surveyor, Heywood.
*SHACKLETON, C. W.	Surveyor to Urban District Council, Coseley.
SHARMAN, E.	Surveyor to Urban District Council, Wellingborough, Northamptonshire.
SHARPE, J. E.	Surveyor to Urban District Council, Otley.
SHAW, H., Assoc.M.Inst.C.E.	Surveyor to Urban District Council, Ilford.
SHAW, J. H.	Surveyor to the Urban District Council, Brownhills, Staffs.
SHEARD, W. C., Assoc.M. Inst. C.E.	Surveyor to the Urban District Council, Heaton Norris, Stockport.
SHEPHERD, G. J.	Surveyor to the Rural District Council, Kidderminster.
SHEPPARD, G.	Borough Surveyor, Newark.
SHILLINGTON, H., M.E. ..	Town Surveyor, Lurgan, Ireland.
SHIPTON, T. H.	Surveyor to the Urban District Council, Oldbury.
SIDDONS, J. M.	Surveyor, Oundle.
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Smail, J. M.	Chief Engineer to the Metropolitan Board of Works, Sydney, N.S.W.
Smales, J. E...	Surveyor to the Urban District Council, Ware.
Smillie, J. F.	Borough Surveyor, Tynemouth.
Smith, Arthur	Surveyor to Rural District Council, Mutford and Lothingland.
Smith, C. Chambers	Surveyor to the Urban District Council, Sutton, Surrey.
Smith, H. W.	Borough Engineer, Scarborough.
Smith, J., Assoc. M. Inst. C.E.	County Surveyor, Co. Galway (E. Riding), Ballinasloe.
Smith, J.	Borough Surveyor, Buckingham.
Smith, J. B.	Surveyor to Urban District Council, Tyldesley.
Smith, J. C., A.M. Inst. C.E.	Borough Surveyor, Bury St. Edmunds.
Smith, J. D., ...	County Road Surveyor, Wigtownshire. 1 Newton Terrace, Stranraer.
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Smith, T. R., A.M. Inst. C.E.	Surveyor to the Urban District Council, Kettering.
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Southam, A., A.M. Inst. C.E.	Surveyor, Clapham, S.W.
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Stead, S.	33 James Street, Harrogate.
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Stevens, G.	Surveyor to Urban District Council, Abercarn, Mon.
Stevens, L.	Surveyor to the Urban District Council, Newton Abbott, Devon.
Stevenson, A.	District Surveyor, Ayrshire County Council.
Stevenson, J.	Surveyor to the Urban District Council, East Molesey.
Stickland, E. A., Assoc. M. Inst. C.E.	Borough Surveyor, Windsor.
Stilgoe, H. E., A.M.Inst.C.E.	Borough Engineer and Surveyor, Dover.
Stirrat, J.	Municipal Engineer, Rangoon.
Stiven, E. E.	Borough Surveyor, Whitehaven.
Stokoe, J.	Surveyor to Urban District Council, Altrincham.
Story, J. S., M. Inst. C.E. ..	County Surveyor, Derby.
Stow, J. F.	Surveyor to Urban District Council, Chertsey.
*Stringfellow, W., Assoc. M. Inst. C.E.	Surveyor to the Urban District Council, Eastleigh, Hants.
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TOOLEY, H.	Surveyor to the Urban District Council, Buckhurst Hill, Essex.
TOWLSON, S., A.M. Inst. C.E.	Surveyor to the Urban District Council, Cheshunt.
TRAVERS, W. H.	Surveyor to Urban District Council, Wallasey.
TRESSIDER, W. H.	Borough Surveyor, Falmouth.
TRINDER, C. D. M.	Surveyor to the Rural District Council, Claypole, Newark.
TURLEY, A. C., A.M.Inst.C.E.	City Engineer, Canterbury.
TURNBULL, A. J.	Borough Engineer, Greenock.
TURNER, H. H.	Surveyor to Rural District Council, Stockport.
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WALKER, A. H.	Borough Surveyor, Loughborough.
WALKER, T., M. Inst. C.E.	Borough Surveyor, Croydon, Surrey.

WALLACE, G.	Surveyor to St. Giles' District Board of Works.
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WARD, J.	Borough Engineer, Derby.
WARDLE, J. W., A.M.Inst.C.E.	Borough Surveyor, Longton.
WARNE, D.	Surveyor, South Taunton, Okehampton.
WATERHOUSE, D.	Surveyor to the Urban District Council, Watford.
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WEBB, J. A.	Surveyor to the Rural District Council, Hendon. Great Stanmore
WEBSTER, R. J.	Surveyor to the Urban District Council, Castleton, Manchester.
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WHITE, J. N.	Borough Surveyor, Stalybridge.
WHITE, W. H., M. Inst. C.E. (*Past President.*)	City Engineer, Oxford.
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WILLIAMS, J. B.	Borough Surveyor, Daventry.
WILLIAMS, J.	Surveyor to the Urban District Council, Mountain Ash.
WILLIAMS, M.	Surveyor to Urban District Council, Bridgend.
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*WILSON, C. L. N., Assoc. M. Inst. C.E.	Town Surveyor, Bilston.

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WOOD, A. R.	Surveyor to the Urban District Council, Tunstall.
WOOD, F. J., A. M. Inst. C.E.	County Surveyor, Sussex East. Lewes.
WOOD, W. E.	Surveyor to the Urban District Council, Church.
WOODS, E. L.	Town Surveyor, Bangor, Co. Down.
WOODBRIDGE, C. A.	Surveyor, Pinner, Middlesex.
WOODWARD, F.	Surveyor to Urban District Council, Stourbridge.
*WORRALL, E.	Surveyor to Urban District Council, Penmaenmawr.
WORTH, J. E., M. Inst. C.E.	District Engineer, London County Council, Spring Gardens, S.W.
*WRIGHT, J. A.	Surveyor to the Urban District Council, Horfield.
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YOUNG, T.	Surveyor to Rural District Council, Sunderland.
YOUNG, J.	Borough Surveyor, Ayr.
YOUNG, W. P.	Surveyor to Urban District Council, Hoyland Nether.

TOWNS AND DISTRICTS

REPRESENTED BY MEMBERS OF THE ASSOCIATION.

H.	*signifies*	Home District.	West	*signifies*	Western District.
Met.	„	Metropolitan District.	N.	„	Northern District.
M.	„	Midland District.	E.	„	Eastern District.
Y.	„	Yorkshire District.	W.	„	Welsh District.
L. & C.	„	Lancashire and Cheshire District.	I.	„	Irish District.
			A.	„	Abroad.

TOWN.	DISTRICT.	NAME.
Abercarne	West.	G. Stevens.
Aberdeen	N.	W. Dyack.
Abergavenny	West.	J. Haigh.
Abersychan	W.	E. Cooke.
Abingdon	H.	G. Winship.
Abram	L. & C.	G. Heaton.
Accrington	L. & C.	W. J. Newton.
Acton	H.	D. J. Ebbetts.
Airdrie, N.B.	N.	C. Brown.
Aldershot	H.	N. F. Dennis.
Alnwick	N.	G. Wilson.
Altofts	Y.	W. Wilkinson.
Altrincham	L. & C.	J. Stokoe.
Andover	H.	R. W. Knapp.
Antrim (County)	I.	J. H. Brett.
Armagh	I.	J. C. Boyle.
Armagh (County)	I.	R. H. Dorman.
Arnold (Notts)	M.	J. E. Fothergill.
Ashby-de-la-Zouch	M.	G. H. Lilley.
Ashford	H.	W. Terrill.
Ashington	N.	A. Wood.
Ashton-under-Lyne	L. & C.	J. T. Earnshaw.
Ashton-in-Makerfield	L. & C.	J. W. Liversedge.
Ashton-upon-Mersey	L. & C.	J. Diggle.
Aston Manor	M.	G. H. Jack.
Atherton	L. & C.	W. Clough.
„	L. & C.	F. H. Grimshaw.
Axholme, Isle of (Rural)	E.	W. Atkinson.
Aylesbury	H.	J. H. Bradford.
Ayr	N.	J. Young.
Ayrshire (County)	N.	A. Stevenson.
Banbury	H.	N. H. Dawson.
Bangor (Co. Down)	I.	E. L. Woods.
Barking	H.	C. F. Dawson.

TOWN.	DISTRICT.	NAME.
Barnes	H.	G. B. Tomes.
Barry	W.	J. C. Pardoe.
Barton Regis (Rural)	West.	A. P. I. Cotterell.
Barton-upon-Irwell (Rural)	L. & C.	C. C. Hooley.
Basford (Rural)	M.	G. W. Hawley.
Basingstoke	H.	G. Fitton.
„ (Rural)	H.	R. Forrester.
Battersea	Met.	J. T. Pilditch.
Beckenham	H.	J. A. Angell.
Bedford	H.	J. Lund.
„ (County)	H.	W. H. Leete.
Bedlingtonshire	N.	C. Brown.
Belfast	I.	J. C. Bretland.
Belper	M.	T. Fenn.
„ (Rural)	M.	R. C. Cordon.
Benwell	N.	W. P. Pattison.
Bermondsey	Met.	R. J. Angel.
Berwick-on-Tweed	N.	R. Dickinson.
Bethnal Green	Met.	F. W. Barratt.
Beverley (Rural)	Y.	E. Picker.
Bexhill	H.	G. Ball.
Bexley	H.	W. T. Howse.
Biddulph	M.	S. Gibson.
Biggleswade	H.	F. B. Rothera.
„ (Rural)	H.	J. O. Jones.
Bilston	M.	C. L. N. Wilson.
Birkenhead	L. & C.	C. Brownridge.
Birmingham	M.	J. Price.
Bishop's Castle	M.	A. Hamar.
Bishop's Stortford	H.	R. S. Scott.
„ „ (Rural)	H.	E. T. Watts.
Blackburn	L. & C.	W. Stubbs.
Blackpool	L. & C.	J. S. Brodie.
Blackwell (Rural)	M.	H. Silcock.
Blean (Rural)	H.	H. T. Sidwell.
Bloemfontein, South Africa	A.	H. F. Peet.
Blyth and Cuckney (Rural)	M.	F. Hopkinson.
Bognor	H.	O. A. Bridges.
Bombay	A.	M. C. Murzban.
Bootle	L. & C.	J. A. Crowther.
Bournemouth	H.	F. W. Lacey.
Brackley	M.	A. A. Green.
Bradford	Y.	J. H. Cox.
Bradford-on-Avon	West	S. Howard.
Braintree	E.	H. H. Nankivell.
Branksome	West.	S. J. Newman.
Bray	I.	P. F. Comber.
Brentford	H.	N. Parr.
Brentwood	E.	S. Turner.
Bridgend	W.	M. Williams.
Bridgwater	West.	F. Parr.
Bridlington	Y.	E. R. Matthews.
Brierfield	L. & C.	J. T. Landless.
Brighton	H.	F. J. C. May.
Bristol	West.	T. H. Yabbicom.
Briton Ferry	W.	H. A. Clarke.
Broadstairs	H.	H. Hurd.
Bromley	H.	S. T. Hawkings.
Bromyard	M.	J. D. Barrs.
Broughty Ferry, N.B.	N.	D. Winning.

TOWN.	DISTRICT.	NAME.
Brownhills	M.	J. H. Shaw.
Buckhurst Hill	E.	H. Tooley.
Buckingham	M.	J. Smith.
Buckingham (County)	H.	R. J. Thomas.
Bucklow (Rural)	L. & C.	J. McD. McKenzie.
Burnham	West.	W. J. Press.
Burnley	L. & C.	G. H. Pickles.
„ (Rural)	L. & C.	S. Edmondson.
Burslem	M.	F. Bettany.
Burton-on-Trent	M.	G. T. Lynam.
Bury St. Edmunds	E.	J. C. Smith.
Buxton	M.	W. H. Grieves.
Caerphilly	W.	A. O. Harpur.
Calcutta	A.	T. C. Deverell.
Camberwell	Met.	W. Oxtoby.
Cannock, Staffs. (Rural)	M.	H. M. Whitehead.
Canterbury	H.	A. C. Turley.
Cape Town, S.A.	A.	R.O.Wynne-Roberts.
Cardiff	W.	W. Harpur.
„ (Rural)	W.	W. Fraser.
Carlisle	N.	H. C. Marks.
Carlton	M.	R. Whitbread.
Carnarvonshire (County)	W.	E. Evans.
Castleford	Y.	W. Green.
Castleton	L. & C.	R. J. Webster.
Caversham	H.	S. P. Andrews.
Chadderton	L. & C.	W. Eckersley.
Charlton	Met.	J. Rowland.
Chatham	H.	C. Day.
Cheadle	L. & C.	E. Sykes.
Chelmsford	E.	G. H. Sasse.
„ (Rural)	E.	J. Dewhirst.
Chelsea	Met.	T. W. E. Higgens.
Cheltenham	West.	J. Hall.
Chepstow	W.	F. Feather.
Chertsey	H.	J. F. Stow.
Chesham	H.	P. C. Dormer.
Cheshire (County)	L. & C.	H. F. Bull.
Cheshunt	H.	S. Towlson.
Chester	L. & C.	I. M. Jones.
Chesterton (Rural)	E.	J. Dunn.
Chichester	H.	J. Saunders.
Chorley	L. & C.	W. Leigh.
Christchurch	H.	E. I. Legg.
Church	L. & C.	W. E. Wood.
Clacton-on-Sea	E.	A. R. Robinson.
Clapham	Met.	A. Southam.
Clayton-le-Moors	L. & C.	A. Dodgeon.
Claypole (Rural)	E.	C. D. M. Trinder.
Cleckheaton	Y.	C. Lund.
Cleethorpes	E.	E. Rushton.
Clerkenwell	Met.	P. G. Killick.
Coalville	M.	L. L. Baldwin.
Coburg (Victoria)	A.	W. M. Pullar.
Cockermouth (Rural)	N.	J. B. Wilson.
Colchester	E.	H. Goodyear.
Colne	L. & C.	T. H. Hartley.
Colombo (Ceylon)	A.	F. A. Cooper.

TOWN.	DISTRICT.	NAME.
COLOMBO (Ceylon)	A.	R. Skelton.
COLWYN BAY	W.	W. Jones.
CONGLETON	L. & C.	R. Burslam.
CONWAY	W.	T. B. Farrington.
COOKHAM (Rural)	H.	F. Laurens.
CORK	I.	H. A. Cutler.
„ (County), West	I.	R. W. Longfield
„ „ South	I.	S. A. Kirkby.
COSELEY	M.	C. W. Shackleton.
COTTINGHAM	Y.	J. H. Hanson.
COWPEN	N.	R. Grieves.
CREWE	L. & C.	G. Eaton-Shore.
CROMER	E.	A. F. Scott.
CROMPTON	L. & C.	J. H. Mills.
CROYDON	H.	T. Walker.
„ (Highways)	H.	E. F. Morgan.
„ (Rural) (Highways)	H.	S. Stallard.
„ (Rural)	H.	R. M. Chart.
CUMBERLAND (County)	N.	G. J. Bell.
CUPAR (Fife) (County)	N.	T. Aitken.
DARTFORD	H.	W. Harston.
DAVENTRY	M.	J. B. Williams.
DARWEN	L. & C.	R. W. Smith-Saville.
DEAL	H.	T. C. Golder.
DENTON	L. & C.	G. H. Newton.
DERBY	M.	J. Ward.
„ (County)	M.	J. S. Story.
DESBOROUGH	M.	D. J. Diver.
DEVON (County)	West.	W. Ingham.
DEWSBURY	Y.	H. Dearden.
DISLEY (Rural)	L. & C.	G. M. Collins.
DONCASTER (Highways)	Y.	W. Crabtree.
„ (Rural)	Y.	C. C. Barras.
DORCHESTER	West.	G. J. Hunt.
„ (Rural)	H.	D. Hinchliffe.
DORKING	H.	G. S. Mathews.
„ (Rural)	H.	W. Rapley.
DOUGLAS, ISLE OF MAN	L. & C.	A. E. Prescott.
DOVER	H.	H. E. Stilgoe.
DOWN (County)	I.	J. Heron.
DRIFFIELD (Rural)	Y.	T. C. Beaumont.
DROITWICH	M.	T. P. Baylis.
DRUMCONDRA	I.	M. J. Buckley.
DUBLIN	I.	S. Harty.
„ (County)	I.	W. Collen.
DUDLEY	M.	J. Gammage.
DUKINFIELD	L. & C.	S. Hague.
DUMBARTONSHIRE (County)	N.	A. Wilson.
DUNFERMLINE (County)	N.	D. MacKenzie.
„	N.	A. W. Bell.
DURHAM (Rural)	N.	G. Gregson.
EALING	H.	C. Jones.
EAST BARNET VALLEY	H.	H. York.
EAST HAM	H.	A. H. Campbell.
EAST LONDON, CAPE COLONY	A.	J. Powell.
EASTLEIGH	H.	W. Stringfellow.
EAST MOLESEY	H.	J. Stevenson.

TOWN.	DISTRICT.	NAME.
East Stonehouse	West.	A. W. Debnam.
East Stow (Rural)	E.	G. F. P. Harrison.
Eastbourne	H.	R. M. Gloyne.
East Retford (Rural)	M.	T. Henry.
Ebbw Vale	W.	T. J. Thomas.
Eccleshill	Y.	F. T. Elliott.
Edgware	H.	B. Wyand.
Edinburgh	N.	J. Cooper.
Elgin, N.B.	N.	A. A. Turriff.
Eltham	Met.	R. Findlay.
Enfield	H.	R. Collins.
Epsom	H.	E. R. Capon.
Erdington	M.	H. H. Humphries.
Erith	H.	H. Hind.
Eston	Y.	C. McDermid.
Eton (Rural)	H.	R. Hallam.
Eton (R.D.C.) (Highways)	H.	A. Gladwell.
Evesham	M.	R. C. Mawson.
Exeter	West.	D. Cameron.
Exmouth	West.	W. D. Harding.
Falmouth	West.	W. H. Tressider.
Fareham	H.	W Butler.
Farnborough	H.	J. E. Hargreaves.
Farnham	H.	R. W. Cass.
Felixstowe	E.	G. S. Horton.
Fenny Stratford	H.	J. Chadwick.
Fermanagh	I.	J. P. Burkitt.
Filey	Y.	A. S. Clarson.
Finchley	H.	F. Smythe.
Folkestone	H.	A. E. Nichols.
Friern Barnet	H.	E. J. Reynolds.
Frome	West.	P. Edinger.
Fulham	Met.	C. Botterill.
Galway (County), West	I.	J. Perry.
" " East	I.	J. Smith.
Gateshead-on-Tyne	N.	J. Bower.
Glamorgan (County)	W.	T. L. Edwards.
Glasgow	N.	A. B. McDonald.
Glastonbury	West.	G. Alves.
Gloucester	West.	R. Read.
" (County)	West.	R. Phillips.
Glyncorrwg	W.	W. P. Jones.
Godalming	H.	J. H. Norris.
Godaveri, Madras	A.	P. H. Brown.
Gosforth	N.	C. J. Baff.
Gosport and Alverstoke	H.	H. Frost.
Grantham	E.	F. J. Morris.
Grays Thurrock	H.	A. C. James.
Great Crosby	L. & C.	W. Hall.
Great Grimsby	E.	H. G. Whyatt.
Great Yarmouth	E.	J. W. Cockrill.
Greenock	N.	A. J. Turnbull.
Grey Co., New Zealand	A.	J. Higgins.
Guernsey	H.	T. J. Guilbert.
Guildford	H.	C. G. Mason.
" (Rural)	H.	J. Anstee.

TOWN.	DISTRICT.	NAME.
Hackney	Met.	N. Scorgie.
Hailsham (Rural)	H.	J. Huxley.
Hale	L. & C.	F. Lobley.
Halifax (Rural)	Y.	F. Gordon.
Halstead	E.	H. Webb.
Hammersmith	Met.	H. Mair.
Hampstead	Met.	C. H. Lowe.
Hampton	H.	J. Kemp.
Handsworth	M.	H. Richardson.
Hanley	M.	J. Lobley.
Hants (County)	H.	W. J. Taylor.
Hanwell	H.	S. W. J. Barnes.
Harrow	H.	J. P. Bennetts.
"	H.	E. Lines.
Harwich	E.	H. Ditcham.
Hastings	H.	P. H. Palmer.
Haverhill	E.	T. Cockrill.
Hayward's Heath	H.	H. W. Bowen.
Heaton Norris	L. & C.	W. C. Sheard.
Hebden Bridge	Y.	W. Calvert.
Heckmondwike	Y.	J. Saville.
Hemel Hampstead	M.	W. R. Locke.
Hendon	H.	S. S. Grimley.
" (Rural)	H.	J. A. Webb.
Hengoed *viâ* Cardiff (Rural)	W.	J. P. Jones.
Henley-on-Thames	H.	R. Pratt.
Hereford	M.	J. Parker.
" (County)	M.	A. Dryland.
Herne Bay	H.	F. W. J. Palmer.
Hertford	H.	J. H. Jevons.
Heston and Isleworth	H.	W. A. Davies.
Heysham	L. & C.	H. G. N. Lailey.
Heywood	L. & C.	J. A. Settle.
High Wycombe	H.	T. J. Rushbrooke.
Higham Ferrers	M.	C. Dunkley.
Hinckley	M.	F. C. Cook.
Hoddesdon	E.	T. Salkield.
Holborn	Met.	L. H. Isaacs.
Holmfirth	Y.	G. E. Vint.
Holyhead	W.	A. Asquith.
Horfield	West.	J. A. Wright.
Hornsea	Y.	P. Gaskell.
Hornsey	H.	E. J. Lovegrove.
Horsham	H.	R. Renwick.
Houghton-le-Spring	N.	V. Smith.
Hove	H.	H. H. Scott.
Howrah (Bengal)	A.	F. Cartwright.
Hoylake and West Kirby	L. & C.	T. Foster.
Hoyland Nether	Y.	W. P. Young.
Huddersfield	Y.	K. F. Campbell.
Hull	Y.	A. E. White.
Hyde	L. & C.	J. Mitchell.
Hythe	H.	A. S. Butterworth.
Islington (St. Mary)	Met.	J. P. Barber.
Ilford	E.	H. Shaw.
Ilfracombe	West.	O. M. Prouse.
Ilkeston	M.	H. J. Kilford.
Ipswich	E.	E. Buckham.

TOWN.	DISTRICT.	NAME.
Isle of Thanet (Rural)	H.	L. W. Hogbin.
Isle of Wight (County)	H.	F. Newman.
Itchen	H.	T. A. Collingwood.
Johannesburg, S.A.	A.	C. Aburrow.
Kearsley	L. & C.	H. Nuttall.
Keighley	Y.	W. H. Hopkinson.
Kendal	N.	R. H. Clucas.
Kensington	Met.	W. Weaver.
Kent (County)	H.	F. W. Ruck.
Keswick	N.	W. Hodgson.
Kettering	M.	T. R. Smith.
Keynsham (Rural)	West.	H. M. Bennett.
Kidderminster (Rural)	M.	A. Comber.
Kilkenny (County)	I.	A. M. Burden.
King's Lynn	E.	H. J. Weaver.
Kingston (Highways)	H.	A. J. Henderson.
Kingston-on-Thames	H.	J. N. Horsfield.
" " (Rural)	H.	W. H. Hope.
King's Norton	M.	A. W. Cross.
Kingston, Jamaica	A.	C. V. Abrahams.
Kirkcaldy	N.	J. L. Lumsden.
Lancashire (County)	L. & C.	W. H. Schofield.
Lancaster	L. & C.	J. Cook.
Lanchester (Highways)	N.	W. Cumming.
Lee	M.	W. G. Forder.
Leeds	Y.	T. Hewson.
Leek	M.	J. Myatt.
Leicester	M.	E. G. Mawbey.
Leigh	L. & C.	T. Hunter.
Leith	N.	W. Beatson.
Leitrim (County)	I.	E. O'N. Clarke.
Levenshulme	L. & C.	J. Jephson.
Lewes	H.	D. Roberts.
Lewisham	Met.	J. Carline.
Leyland	L. & C.	W. H. Wilkinson.
Leyton	H.	W. Dawson.
Limehouse	Met.	T. H. Dunch.
Limerick (County)	I.	J. Horan.
Lincoln	E.	R. A. MacBrair.
" (County)	E.	J. Thropp.
Littleborough	L. & C.	G. H. Wild.
Littlehampton	H.	H. Howard.
Llandaff (Rural)	W.	W. Fraser.
Llandaff (Rural) (Highways)	W.	J. Holden.
Llandudno	W.	E. P. Stephenson.
Llanelly	W.	G. Watkeys.
Llantrissant	W.	G. S. Morgan.
Loftus	Y.	T. H. Tarbit.
London (County)	Met.	Sir A. R. Binnie.
Londonderry	I.	W. J. Robinson.
Longford (County)	I.	J. W. Gunnis.
Longton	M.	J. W. Wardle.
Loughborough	M.	A. H. Walker.
Louth (County)	I.	P. J. Lynam.

TOWN.	DISTRICT.	NAME.
Lower Bebington	L. & C.	H. W. Corrie.
Lowestoft	E.	G. H. Hamby.
Lurgan	I.	H. Shillington.
Luton	H.	A. J. L. Evans.
Lymington	H.	I. Pym-Jones.
Lynton	West.	W. H. Chowins.
Lytham	L. & C.	A. J. Price.
Macclesfield	L. & C.	E. E. Adshead.
" (Rural)	L. & C.	J. Thorpe.
Maesteg	W.	J. Humphreys.
Maidstone	H.	T. F. Bunting.
" (Rural)	H.	J. S. Killick.
Maldon (Rural)	E.	H. G. Keywood.
Malton	H.	R. Richardson.
Malvern	M.	H. P. Maybury.
Manchester	L. & C.	T. De C. Meade.
Mansfield	M.	R. F. Vallance.
Mansfield Woodhouse	M.	F. P. Cook.
Margam, Port Talbot	W.	J. Cox.
Margate	H.	A. Latham.
Market Harborough	M.	H. G. Coales.
Marylebone	Met.	J. A. P. Waddington.
Matlock Bath	M.	W. Jaffrey.
Meath (County)	I.	J. H. Moore.
Melbourne	A.	W. Thwaites.
Melton Mowbray	M.	E. Jeeves.
Merthyr Tydvil	W.	T. F. Harvey.
Methley	Y.	T. W. Nichols.
Mexborough	Y.	G. F. Carter.
Middlesbrough	Y.	F. Baker.
Middlesex (County)	H.	H. T. Wakelam.
Middleton	L. & C.	W. Welburn.
Midsomer Norton	West.	W. F. Bird.
Mile End	Met.	J. M. Knight.
Milton-next-Sittingbourne	H.	W. A. Farnham.
Mirfield	Y.	F. H. Hare.
Monmouthshire (County)	W.	W. Tanner.
Montgomery	W.	W. P. Hole.
Morley	Y.	W. E. Putman.
Morpeth	N.	W. F. Curry.
Mountain Ash	W.	J. Williams.
Mutford & Lothingland (Rural)	E.	A. Smith.
Nantwich	L. & C.	W. F. Newey.
Neath	W.	D. M. Jenkins.
" (Rural)	W.	W. E. C. Thomas.
Nelson	L. & C.	B. Ball.
New Swindon	H.	H. J. Hamp.
Newark	M.	G. Sheppard.
" (Rural)	M.	R. Oakden.
Newburn-on-Tyne	N.	T. Gregory.
Newbury	H.	S. J. L. Vincent.
Newcastle-on-Tyne	N.	W. G. Laws.
Newhaven	H.	F. J. Rayner.
Newmarket	E.	J. W. Metcalf.
Newport, Mon.	West.	R. H. Haynes.

TOWN.	DISTRICT.	NAME.
NEWTON ABBOTT	West.	L. Stevens.
NEWTOWN, ST. BOSWELLS, N.B.	N.	G. Monteath.
NORFOLK (County)	E.	T. H. B. Heslop.
NORTH BIERLEY	Y.	P. Ross.
NORTH MAYO (County)	I.	W. P. Orchard.
NORTHAMPTON	M.	W. I. Brown.
,, (County)	M.	E. Law.
NORTHWICH	L. & C.	J. Brooke.
NORWICH	E.	A. E. Collins.
NOTTINGHAM	M.	A. Brown.
,, (County)	M.	E. P. Hooley.
NUNEATON	M.	J. S. Pickering.
OAKWORTH	Y.	J. Spencer.
OGMORE AND GARRW	W.	H. D. Williams.
OKEHAMPTON	West.	H. Geen.
OLDBURY	M.	T. H. Shipton.
OLDHAM	L. & C.	S. A. Pickering.
OSWESTRY	M.	G W. Lacey.
OTLEY	Y.	J. E. Sharp.
OXFORD	H.	W. H. White.
OYSTERMOUTH	W.	J. Stansfield-Brun.
PADDINGTON	Met.	G. Weston.
PADIHAM	L. & C.	J. Gregson.
PEEBLES (County)	N.	R. S. Anderson.
PEMBERTON	L. & C.	G. Heaton.
PENANG, STRAITS SETTLEMENTS ..	A.	R. Peirce.
PENARTH	W.	E. I. Evans.
PENMAENMAWR	W.	E. Worrall.
PERRY BARR	M.	H. H. Gammell.
PERTH, N.B.	N.	R. McKillop.
PEITERMARITZBURG	A.	G. B. Laffan.
PETERBOROUGH	M.	J. W. Walshaw.
PLUMSTEAD	Met.	W. C. Gow.
,, ...	Met.	F. Summer.
PLYMOUTH	West.	J. Paton.
POKESDOWN	H.	E. W. Ingamells.
PONTARDAWE (Rural)	W.	J. Morgan.
PONTYPRIDD	W.	E. Rees.
POOLE	West.	J. Elford.
POPLAR	Met.	O. E. Winter.
PORTMADOC	W.	T. Harris.
PORTSLADE-BY-SEA	H.	A. T. Allen.
PORTLAND	West.	E. J. Elford.
PORTSMOUTH	H.	P. Murch.
PRESCOT	L. & C.	W. Goldsworth.
PRESTWICH	L. & C.	W. Nuttall.
PUTNEY	Met.	J. C. Radford.
PWLLHELI	W.	W. J. Davies.
QUEEN'S COUNTY	I.	H. V. White.
QUEENSTOWN, SOUTH AFRICA ..	A.	W. A. Palliser.
RANGOON	A.	J. Stirrat.
RAWMARSH	Y.	W. J. Petch.

TOWN.	DISTRICT.	NAME.
Rawtenstall	L. & C.	A. W. Lawson.
Redditch	M.	B. Perrins.
Redcar	Y.	J. Howcroft.
Redruth	West.	T. C. Jones.
Reigate	H.	W. H. Prescott.
Retford	M.	J. D. Kennedy.
Rhondda	W.	W. J. Jones.
Rhymney	W.	W. L. Marks.
Rhyl	W.	R. Hughes.
Richmond, Surrey	H.	J. H. Brierley.
Richmond, Yorks.	Y.	J. W. Wetherill.
Ripon	Y.	W. Edson.
Rochdale	L. & C.	S. S. Platt.
Rochester	H.	W. Banks.
Romford (Rural)	E.	E. G. Boden.
Roscommon (County)	I.	C. J. Mulvany.
Rotherham	Y.	G. Jennings.
" (Rural)	Y.	B. Godfrey.
Rotherhithe	Met.	G. W. Thompson.
Rothwell, Northants	M.	W. T. Pearson.
Rowley Regis	M.	W. H. Brettell.
Rugby	M.	D. G. MacDonald.
Rugeley	M.	W. E. Rogers.
Runcorn	L. & C.	J. Wilding.
Rushden	M.	W. B. Madin.
Ryde	H.	C. Mathew.
Ryton-on-Tyne	N.	J. P. Dalton.
St. Albans	H.	G. Ford.
St. George, Hanover Square	Met.	G. Livingstone.
St. Giles	Met.	G. Wallace.
St. Helen's, Lancs.	L. & C.	G. J. C. Broom.
" Isle of Wight	H.	J. I. Barton.
St. Martin-in-the-Fields	Met.	G. Green.
St. Mary, Islington	Met.	J. P. Barber.
St. Neots (Hunts)	L.	A. T. Blood.
St. Pancras	Met.	W. N. Blair.
Saffron Walden	E.	A. H. Forbes.
Salford	L. & C.	J. Corbett.
Saltburn-by-the-Sea	Y.	G. S. L. Bains.
Sandgate	H.	A. R. Bowles.
Scarborough	Y.	H. W. Smith
Sevenoaks	H.	J. Mann.
Shanghai, China	A.	C. Mayne.
Shanklin	H.	E. C. Cooper.
Sheffield	Y.	C. F. Wike.
Sherborne	West.	T. Farrall.
Shoreditch	Met.	J. R. Dixon.
Shrewsbury	M.	W. C. Eddowes.
Shropshire (County)	M.	A. T. Davis.
Singapore	A.	S. Tomlinson.
Skelton-in-Cleveland	Y.	W. P. Robinson.
Skipton	Y.	J. Mallinson.
" (Rural)	Y.	A. Rodwell.
Sleaford	E.	J. Clare.
Slough	H.	W. W. Cooper.
Smallthorne	M.	J. Deane.
Smethwick	M.	C. J. Fox-Allin.
Solihull (Rural)	M.	A. E. Currall.

TOWN.	DISTRICT.	NAME.
South Shields	N.	S. E. Burgess.
Southall Norwood	H.	H. R. Felkin.
Southampton	H.	W. B. G. Bennett.
Southend-on-Sea	H.	A. Fidler.
Southgate	H.	C. G. Lawson.
Southowram	Y.	W. H. D. Horsfall.
Southport	L. & C.	R. P. Hirst.
Southwark, St. Olave	Met.	G. W. Thompson.
„ St. Saviour	Met.	G. R. Norrish.
Southwold	E.	F. Ball.
Spalding	E.	J. S. Hélé.
„ (Rural)	E.	T. J. Peacock.
Spilsby (Rural)	E.	T. A. Busbridge.
Stafford	M.	W. Blackshaw.
Stafford (County) (Highways)	M.	J. Moncur.
Staines (Rural)	H.	G. W. Manning.
Stalybridge	L. & C.	J. N. White.
Stamford	E.	J. Richardson.
Stirling	N.	A. H. Gondie.
Stirlingshire (Highways)	N.	R. M. Reid.
Stockport	L. & C.	J. Atkinson.
Stockport (Rural)	L. & C.	H. H. Turner.
Stockton-on-Tees	N.	M. H. Sykes.
Stoke (Rural)	M.	W. L. Sugden.
Stoke Newington	Met.	R. Brown.
Stone	L. & C.	A. R. Ridout.
Stourbridge	M.	F. Woodward.
Strand	Met.	A. Ventris.
Stratford-on-Avon	M.	R. Dixon.
Streatham	Met.	H. J. Marten.
Stretford	M.	H. Royle.
Strood (Rural)	H.	W. Brooke.
Stroud	West.	G. P. Milnes.
Sudbury (Suffolk)	E.	T. W. A. Hayward.
Suffolk (County), East	E.	H. Miller.
Sunbury-on-Thames	H.	H. F. Coales.
Sunderland (Rural)	N.	T. Young.
Surrey (County)	H.	F. G. Howell.
Sussex (County), East	H.	F. J. Wood.
„ (County) West	H.	W. B. Purser.
Sutton	H.	C. C. Smith.
Sutton Coldfield	M.	W. A. H. Clarry.
Sutton-in-Ashfield	M.	McW. Bishop.
Swadlincote	M.	T. Kidd.
Swanage	West.	J. S. Senior.
Swansea	W.	G. Bell.
Swinton	L. & C.	H. Entwisle.
Sydney, N.S.W.	A.	R. W. Richards.
„ „	A.	J. M. Smail.
Tadcaster (Rural)	Y.	T. Scott.
Tamworth	M.	H. J. Clarson.
Teddington	H.	M. Hainsworth.
Teignmouth	West.	C. Jones.
Tenbury (Rural)	M.	R. W. Jarvis.
Tenby	W.	J. P. James.
Tettenhall	M.	J. Mortimer.
Thame, Oxon	H.	D. W. Slocombe.
Thornhill	Y.	S. W. Parker.

TOWN.	DISTRICT.	NAME.
TIENTSIN, CHINA	A.	A.W.H. Bellingham.
TIPPERARY (County), South	I.	E. A. Hackett.
TIPTON	M.	W. H. Jukes.
TODMORDEN	L. & C.	C. R. Pease.
TONBRIDGE	H.	W. L. Bradley.
"	H.	A. F. Ginn.
" (Rural)	H.	F. Harris.
TOOWONG, QUEENSLAND	A.	W. E. Irving.
TOKIO FU, JAPAN	A.	R. Hara.
TOTTENHAM	H.	P. E. Murphy.
TROWBRIDGE	West.	F. E. G. Bradshaw.
TUNSTALL	M.	A. R. Wood.
TURTON	L. & C.	V. Laithwaite.
TWICKENHAM	H.	F. W. Pearce.
TYLDESLEY	L. & C.	J. B. Smith.
TYNEMOUTH	N.	J. F. Smillie.
TYRONE (County) North	I.	F. J. Lynam.
" " South	I.	J. W. Leebody.
UPHOLLAND	L. & C.	C. E. Senior.
URMSTON	L. & C.	J. Heath.
UXBRIDGE (Rural)	H.	E. Birks.
ULVERSTON (Rural)	L. & U.	W F. Y. M olineux
VENTNOR	H.	E. J. Harvey.
WAKEFIELD	Y.	R. Porter.
" (Rural)	Y.	F. Massie.
WALLASEY	L. & C.	W. H. Travers.
WALSALL	M.	R. H. Middleton.
" (Rural)	N.	F. W. Mager.
WALLSEND	N.	G. Hollings.
WALTHAMSTOW	H.	G. W. Holmes.
WALTON-ON-THAMES	H.	C. J. Jenkin.
WANDSWORTH	Met.	P. Dodd.
WANSTEAD	H.	J. T. Bressey.
WANTAGE (Rural)	H.	W. Hanson.
WARDLE	L. & C.	V. Wilson.
WARE	H.	J. E. Smales.
WARLEY	E.	J. Eastwood.
WARWICKSHIRE (County)	M.	J. Willmot.
WARRNAMBOOL, MELBOURNE	A.	J. C. Ross.
WATERFORD	I.	M. J. Fleming.
" (County)	I.	W. E. L. Duffin.
WATERLOO, LIVERPOOL	L. & C.	F. S. Yates.
WATFORD	H.	D. Waterhouse.
WATH-UPON-DEARNE	Y.	H. C. Poole.
WEALDSTONE	H.	F. H. Parr.
WELLINGBOROUGH	M.	E. Sharman.
WELLINGTON, NEW ZEALAND	A.	R. S. Rounthwaite.
WEMBLEY	H.	C. R. W. Chapman.
WEST BRIDGFORD	M.	W. Pare.
WEST BROMWICH	M.	A. D. Greatorex.
WEST HARTLEPOOL	N.	J. W. Brown.
WEST MALLING (Rural)	H.	J. Marshall.
WESTMINSTER, ST. JAMES	Met.	H. Monson.

TOWN.	DISTRICT.	NAME.
Westminster, St. Margaret and St. John	Met.	G. R. W. Wheeler.
Weston-super-Mare	West.	H. Nettleton.
Weymouth and Melcombe Regis	West.	W. B. Morgan.
Whitechapel	Met.	M. W. Jameson.
Whitehaven	N.	E. E. Stiven.
Whitworth	L. & C.	T. Biker.
Widnes	L. & C.	J. S. Sinclair.
Wigtownshire (Highways)	N.	J. D. Smith.
Willenhall	M.	T. E. Fellows.
Willesden	H.	O. C. Robson.
Willington Quay	N.	J. F. Davidson.
Wilmslow	L. & C.	A. S. Cartwright.
Wimbledon	H.	C. H. Cooper.
Winchester	H.	W. V. Anderson.
Windsor	H.	E. A. Stickland.
Wing and Eaton Bray (Rural)	H.	J. McKenzie.
Wirksworth	M.	C. H. Lawton.
Wisbech	E.	A. H. Plowright.
Withington	L. & C.	A. H. Mountain.
Witney	H.	G. A. Graham.
Wokingham	M.	J. Manley.
Wolverhampton	M.	J. W. Bradley.
Wood Green	H.	C. J. Gunyon.
Woodford	E.	W. Farrington.
Woollahra, Sydney	A.	J. I. Haycroft.
Woosung, China	A.	W. A. Moller.
Worcester	M.	T. Caink.
„ (County)	M.	J. H. Garrett.
Worksop	M.	F. S. Whittell.
Worsley	L. & C.	J. T. Proffitt.
Worthing	H.	F. Roberts.
Wortley (Rural)	Y.	G. E. Beaumont.
Wrexham	W.	J. W. M. Smith.
„ (Rural)	W.	J. P. Evans.
Yeovil	W.	W. K. L. Armytage.
York	Y.	A. Creer.
„ (Rural)	Y.	W. G. Penty.
Yorkshire, East Riding	Y.	A. Beaumont.
„ West Riding	Y.	J. V. Edwards.

GRADUATES.

Adams, H. C.	37 Waterloo Street, Birmingham.
Ball, J. B., A.M. Inst. C.E.	Engineer's Office, L.D. & E.C. Railway, Chesterfield.
Bayley, G. H., A.M.Inst.C.E.	17 Cooper Street, Manchester.
Beard, E. T., A.M. Inst. C.E.	"Marazion," West Hill, St. Leonards-on-Sea.
Bell, B.	City Surveyor's Office, Carlisle.
Bentley, J.H., A.M.Inst.C.E.	31 Fern Street, Oldham.
Best, H. Storr	7 Church Road, Beckenham.
Birch, J...	Public Offices, East Ham.
Bissell, W. S.	Borough Engineer's Office, Wolverhampton.
Blakeway-Phillips, R. ..	Borough Engineer's Office, Middlesbrough.
Blizard, J. H., A.M.Inst.C.E.	Lansdowne House, Southampton.
Bradshaw, A. S.	Borough Engineer's Office, Bedford.
Bradshaw, J. B., A.M. Inst. C.E.	Headquarters, R. E. Office, Bermuda.
Bowe, D. J.	Town Hall, Eastbourne.
Briscoe, J. T.	Laurel Dene, Southbury Road, Enfield.
Bruce, W.	Borough Engineer's Office, Edinburgh.
Bryans, J. G.	Assistant Engineer, Buenos Ayres and Pacific Railway, Junin, Argentine.
Bryning, W. G.	Higher Bank Road, Fulwood, Preston.
Burgess, R. W.	Town Hall, Stratford, E.
Burton, A., A.M. Inst. C.E.	Town Hall, Hanley.
Bush, W. E.	City Surveyor's Office, Birmingham.
Carter, G. F., A.M.Inst.C.E.	Town Hall, Croydon.
Cartledge, J. R.	Assistant Surveyor, District Council Offices, Barnes.
Catchpole, J. H.	27 Avenue Villas, Avenue Road, Finchley, N.
Chasemore, A. E.	98 High Street, Putney.
Claypoole, A. H., A. M. Inst. C.E.	City Engineer's Office, Bristol.
Clegg, H.	Borough Surveyor's Office, Oldham.
Clews, C. A.	Borough Engineer's Office, Derby.
Collinge, T. P.	Town Hall, Nelson.
Collis-Adamson, A. C. ..	Northgate House, Highgate, N.
Coombs, C. A.	41 Adelaide Street, Todmorden.
Cowan, G.	47 Chelsea Road, Southsea.
Creswell, W. T.	Barrack Reconstruction Offices, Colchester.
Cross, F. W., A.M. Inst. C.E.	The Bridge, Walsall.
Crump, E. H.	Council Offices, Nuneaton.
Cudbird, T. O.	The Refuge, Caernarvon Road, Norwich.
Dent, J. P.	24 Lomeshaye Road, Nelson, Lancashire.
Dolamore, F...	Borough Engineer's Office, Bournemouth.
Dyer, R. H.	Borough Engineer's Office, Southampton.
Ellison, D.	Radfield Mount, Darwen.
Endsor, H. A.	2 Oakland Villas, Rosebery Road, Norwich.
Essex, E. H.	Town Hall, Leyton.

Fell, P. O.	City Engineer's Office, Norwich.
Fenton, W. C.	10 Paradise Square, Sheffield.
Finch, A. R., A.M. Inst. C.E.	Town Hall, Kensington.
Finch, E. E.	Town Hall, Bermondsey.
Fisher, R.	37 Inman Road, Harlesden, N.W.
Foster, H. H.	Borough Engineer's Office, West Hartlepool.
Fox, Senior L.	Town Hall, Newport.
Franck-Clark, A. H.	District Engineer, P.W.D., Ratnapura, Ceylon.
Fraser, R. W.	Town Hall, Wolverhampton.
Gibson, W. S.	"D'Arcyville," Victoria Road, Hendon.
Gibbs, L., Assoc. M. Inst. C.E.	c/o Messrs. Denison and Ram, Hong Kong.
Glass, S. N.	Town Hall William Street, Woolwich, S.E.
Godfrey, C.H., A.M. Inst.C.E.	Municipal Offices, Shanghai.
Goodfellow, H.	Borough Surveyor's Office, Southport.
Gordon, J., A.M. Inst. C.E.	Assistant Burgh Surveyor, Town House, Aberdeen.
Grant, F. T.	Assistant Borough Surveyor, Maidstone.
Greenwood, J. P.	Town Hall, Burnley.
Grimley, F. C.	The Depôt, Harwich.
Haigh, W. H.	Borough Engineer's Office, Cardiff.
Hall, C.	Borough Engineer's Office, Salford.
Harper, A.	Deputy Borough Surveyor, St. Helens.
Harrison, J. W.	2 Ashley Street, Rock Ferry, Cheshire.
Haywood, S. S.	Borough Engineer's Office, Darwen.
Hellawell, O.	Town Hall, Withington, Manchester.
Hendry, J. S.	Town Hall, West Bromwich.
Hills, H. J., A.M. Inst. C.E.	21 Gloucester Road, Philip Lane, Tottenham.
Hills, O. C.	147 Bow Road, E.
Hinchsliff, E. R.	Council Offices, Barry, Glam.
Hobson, E.	117 Broomspring Lane, Sheffield.
Holloway, W. C.	Engineer's Office, Kettering.
Houghton, J	King's Heath, Birmingham.
Hutchings, W. A.	45 Sotheby Road, Highbury Park, N.
Jeffes, R. H.	242 High Street, Acton.
Jenkins, A. J., A.M.Inst.C.E.	Town Hall, Burton-on-Trent.
Jenkins, R. J.	Town Hall, Portsmouth.
Jerram, G.	19 Merton Road, Walthamstow.
Johnston, R. W.	Borough Surveyor's Office, Birkenhead.
Julian, J.	Borough Surveyor's Office, Cambridge.
Kieser, W. H. G.	City Engineer's Office, Bristol.
Killick, W. H.	Borough Surveyor's Office, Southampton.
Kirk, J. W.	Town Hall, Westminster.
Lea, M.	City Surveyor's Office, Truro.
MacDonald, K. G.	13 Charles Street, St. James, S.W.
Marks, C. W.	Clarence Road, Newport, Isle of Wight.
Martin, E. B., A.M.Inst.C.E.	City Engineer's Office, Leeds.
Mattinson, H.	Borough Engineer's Office, Wolverhampton.
Maxwell, W.H., A.M.Inst.C.E.	Borough Engineer, Town Hall, Tunbridge Wells.
May, C. G.	P.W.D., Malacca Straits Settlements.
Miller, G. F.	8 Villa Road, St. Leonard's-on-Sea.
Mitchell, G.	Water Engineer's Office, Warrington.
Moss, P. A.	147 Highbury Hill, Highbury, N.
Newton, E. B.	Vestry Hall, Harrow Road, W.
Nightingale, C. F.	6 Westbourne Road, Walsall.
Openshaw, J., A.M.Inst.C.E.	Borough Engineer's Office, Salford.
Palmer, G. F.	21 Albert Street, Barrow-in-Furness.
Percival, W.	Borough Engineer's Office, Longton, Staffs.
Perkins, J.	85 Willows Road, Balsall Heath, Birmingham.
Perkins, T. L. A.M. Inst. C.E.	4 Linzee Road, Hornsey.
Plant, W.	Borough Engineer's Office, Leicester.
Pritchard, T., A.M.Inst.C.E.	264 Gresham House, Old Broad Street, E.C.
Quick, A. H.	15 Fernholme Road, Newlands, S.E.

RAWSTRON, C. O.	29B High Street, Rotherham.
REDFERN, J. L.	Deputy City Engineer, Carlisle.
RICHARDS, E. P.	Borough Engineer's Office, Southend-on-Sea.
ROSE, J. G.	12 Joannah Street, Sunderland.
ROSS, D.	Brede, Sussex.
ROUSELL, A. J.	Borough Engineer's Office, Worthing, Sussex.
SAVAGE, E. B., A.M.Inst. C.E.	City Engineer's Office, Birmingham.
SLATER, F. J.	Vestry Surveyor's Office, Camberwell.
SIMMS, F...	Town Hall, Sheffield.
SMITH, G. H.	1 Worcester Road, Wimbledon.
SMITH, J. W.	Borough Engineer's Office, Burton-on-Trent.
SPINK, J.	City Surveyor's Office, Manchester.
SPRECKLEY, J. A.	County Surveyor's Office, Hereford.
STANTON, F. W. S...	c/o J. Mansergh, Esq., 5 Victoria Street, S.W.
STEELE, W. J.	Deputy City Engineer, Bristol.
SUTTON, W. F.	Water Department, Broad Street, Birmingham.
SWALES, T. R...	Borough Engineer's Office, Worthing.
TAYLOR, H. G.	16 Church Terrace, Tranmere, Birkenhead.
TAYLOR, J.	Town Hall, Bradford.
TAYLOR, P.	Council Offices, Ilford, Essex.
THACKERAY, F.	43 Richmond Terrace, Darwen.
THACKERAY, J. R.	Borough Engineer's Office, Eastbourne.
TIFFIN, T. E.	York Road, West Hartlepool.
TREMELLING. H.	Borough Engineer's Office, Newport, Mon.
TOMPKINS, H.	Hill Cottage, Cowper Road, Berkhampsted.
TOWNER, H. V.	Assistant Borough Surveyor, Ilkeston.
TWAITES, J.	Vestry Hall, Mile End, E.
VEIT, L. J.	Town Hall, Barrow-in-Furness.
VIDEAN, H. N.	Assistant Borough Surveyor, Folkestone.
WALKER. H.	Whyteleafe, Cecil Road, Wealdstone.
WARD, F. D., A. M. Inst. C.E.	38 High Street, Welshpool.
WARLOW, W. R.	Nolton House, Windmill Road, Brentford.
WARREN, A. R.	73 Breakspears Road, St. Johns, S.E.
WEBB, F.	Town Hall, Chelsea.
WEIR, J. S.	42 Broughton Road, South Shields.
WELLS, F. B.	Farnborough Cottage, Limpsfield, Surrey.
WHITWORTH, W.	Cradley Heath, Staffs.
WILLIAMS, D. S.	Resident Engineer, Sewerage Works, Abercynon, South Wales.
WILLIS, E.	Public Offices, Dyne Road, Kilburn, N.W.
WILLS, A. J.	Essendine, Poole Road, Wimborne, Dorset.
WILSON, F.	City Engineer's Office, Bristol.
WOLFENDEN, B. J.	Borough Engineer's Office, Middlesbrough.
WOOTTON, A. S.	3 South View, Sheldon Road, Chippenham.
WRACK, W. P.	117 High Street, Poplar.
YARWOOD, Hy...	Town Hall, Rochdale.

PARLIAMENTARY AND GENERAL PURPOSES COMMITTEE.

J. P. Barber (Islington), *Chairman.*

Lewis Angell (West Ham).
Chas. Jones (Ealing).
E. G. Mawbey (Leicester).
O. C. Robson (Willesden).
T. Walker (Croydon).
W. Weaver (Kensington).

FINANCE COMMITTEE.

W. Weaver (Kensington), *Chairman.*

J. P. Barber (Islington).
W. Harpur (Cardiff).
C. Jones (Ealing).
J. S. Pickering (Nuneaton).
T. H. Yabbicom (Bristol).

BYE-LAWS.

Membership.

1. Members, Graduates, and Honorary Members of the existing Association may, upon signing and forwarding to the Secretary a claim according to Form F in the Appendix, become Members, Graduates, or Honorary Members respectively of the Association, without election or payment of entrance fees.

Members.

2. Candidates for admission as Members must be Civil Engineers or Surveyors holding chief permanent appointments under any Municipal Corporations, County Councils, or Urban or Rural Sanitary Authorities, and Civil Engineers or Surveyors holding other chief permanent appointments under any Public Authority of the like nature within the United Kingdom, or in the Colonies or foreign countries.

Graduates.

3. Candidates for admission as Graduates must be successful in obtaining certificates of competency at any examination under the auspices of the Association, and who are not otherwise qualified as Members of the Association; and as such shall be entitled to attend the General and District Meetings, and to take part in the proceedings thereof, and be entitled to a copy of the Minutes of Proceedings, but shall not be entitled to vote. Graduates shall at their request become Members of the Association when qualified according to Bye-law 2.

Honorary Members.

4. The Council shall have the power to elect as Honorary Members gentlemen of eminent scientific position or acquirements, who in their opinion are eligible for that position.

5. The Members, Graduates, and Honorary Members shall have notice of and the privilege to attend all Meetings, and be entitled to a copy of the Proceedings of the Association as published.

Entrance Fees and Subscriptions.

6. An Entrance Fee of One Guinea shall be paid by each Member, except Members of the existing Association, who shall pay no Entrance Fee. Each Member shall pay an Annual Subscription of One Guinea.

7. A Graduate shall not be required to pay an Entrance Fee either on his becoming a Graduate or on his becoming a Member. Each Graduate shall pay an Annual Subscription of Half a Guinea.

8. All Subscriptions shall be payable in advance, and shall become due on the 1st day of May in each year; and Members elected between the 1st day of January and the 1st day of May in each year are required to pay an Entrance Fee on Election, their first Subscription being due on the 1st day of May following their Election.

9. The Council may at their discretion reduce or remit the Annual Subscription, or the Arrears of Annual Subscription, of any Member who shall have been a Subscribing Member of the Association for ten years, and shall have become unable to continue the Annual Subscription provided by these Bye-laws.

10. No Proceedings or Ballot Lists shall be sent to Members or Graduates who are in arrear with their Subscriptions more than twelve months, and whose Subscriptions shall not have been remitted by the Council as hereinbefore provided.

Election of Members and Graduates.

11. A recommendation for admission according to Form A for a Member, and Form B for a Graduate, in the Appendix, shall be forwarded to the Secretary, and by him be laid before the next Meeting of the Council.

The recommendation must be signed by not less than Two Members, who from personal knowledge of such Candidate shall certify that he possesses the necessary qualification. Candidates residing outside England and Wales not known by two Members of this Association, may be proposed by three Corporate Members of the Institution of Civil Engineers. Members who cease to hold their appointments are eligible for re-election by the Council, but will be disqualified from holding any Office.

All Elections of Members and Graduates of the Association shall be made by the Council, and shall be decided by a majority of votes of the Members of the Council present and voting.

12. When the proposed Candidate is elected, the Secretary shall give him notice thereof according to Form C; but his name shall not be added to the List of Members or Graduates of the Association until he shall have paid his Entrance Fee and First Annual Subscription as defined by these Bye-laws.

13. A qualified Graduate desirous of becoming a Member shall forward to the Secretary a recommendation according to Form D in the Appendix, signed by not less than two Members, which shall be laid before the next meeting of the Council for their approval. On their approval being given, the Secretary shall notify the same to the Candidate according to Form E. A Graduate on becoming qualified to be a Member shall cease to be a Graduate.

Election of President, Vice-Presidents, and Members of Council.

14. The Council shall nominate one name for President, six for Vice-Presidents, one for Honorary Secretary, and fifteen for Ordinary Members of Council. In addition to these, each Member of the Association shall be at liberty to nominate one Member for the Council, but in the event of the last named nominations exceeding fifteen, the Council shall reduce them to that number, so as to leave thirty names in all from which to elect the required number of Ordinary Members of Council. Members' nominations must be in the hands of the Secretary on or before the 20th of April in each year. And in case the Members' nominations should not reach fifteen, the Council shall have the power to make up the total number of nominations to twenty. Such list of twenty nominations shall be printed and sent to each Member of the Association not less than fourteen days previous to the Annual Meeting. Each Member shall be entitled to vote for or erase any of such Nominations or substitute other names, subject in all cases to the limits of Clause 25 in the Articles of Association, and return the same within seven days from the date of issue. Such Ballot Papers shall be examined in London by the President, Secretaries, and two Scrutineers appointed at the

previous Annual Meeting, or by any two of the aforesaid Members. Any Member canvassing for votes for the office of Member of Council shall be considered ineligible for Election.

Appointment and Duties of Officers.

15. The Treasurer shall hold the uninvested funds of the Association, except the moneys in the hands of the Secretary for current expenses. He shall be appointed by the Members at a General or Special Meeting, and shall hold office at the pleasure of the Council.

16. The Secretary of the Association shall be appointed by the Council, and shall be removable by the Council upon three months' notice from any day. The Secretary, if desirous of resigning his appointment, shall give the same notice. The remuneration of the Secretary shall from time to time be fixed by the Council.

17. It shall be the duty of the Secretary, under the direction of the Council, to conduct the correspondence of the Association; to attend all General and Special Meetings of the Association and of the Council, and of Committees (but not the District Meetings, unless required so to do by the President); to take minutes of the proceedings of such meetings; to read the minutes of the preceding meetings, and all communications that he may be ordered to read; to superintend the publication of such papers as the Council may direct; to direct the collection of the subscriptions, and the preparation of the account of expenditure of the funds; and to present all accounts to the Council for inspection and approval, and generally to do all such other matters as usually pertain to the office of Secretary, or as may be prescribed by the Council.

Examinations.

18. Two or more examinations of Candidates for certificates of competency in Municipal Engineering, Surveying, Building Construction, Sanitary Science and Municipal Law, shall be held annually at such places and at such times as the Council shall appoint.

The Board of Examiners shall be not less than twelve in number, and shall be elected by and be Members of the Council, or such

other Members of the Association as shall be leading men in their particular branch of the Engineering profession. Four or more of such Board shall be selected by the Council to carry out each Examination, who as "Acting Examiners" shall report to the Council the names of those Candidates who have satisfied them of their proficiency.

MISCELLANEOUS.

19. All communications to the meetings shall be the property of the Association, and be published only by the authority of the Council.

20. Seven clear days' notice at least shall be given of every meeting of the Council. Such notice shall specify generally the business to be transacted by the meeting.

21. The Council shall present the yearly accounts to the Members at the Annual General Meeting, after being audited by two auditors, who shall be appointed annually by the Members at their Annual General Meeting.

THE

INCORPORATED ASSOCIATION OF MUNICIPAL AND COUNTY ENGINEERS.

TWENTY-SEVENTH ANNUAL MEETING.

LONDON, *July* 19, 20, *and* 21, 1900.

THE Members assembled in the Westminster Town Hall, when Mr. W. Harpur, President, took the Chair, and the Minutes of the Annual Meeting, held at Cardiff, in June 1899, were read, confirmed and signed.

The Secretary then read the Council's Annual Report for the year ending April 30, 1900.

ANNUAL REPORT.

INTRODUCTORY.

The Council have the pleasure, in presenting the twenty-seventh Annual Report, to record that the steady progress of the Association is satisfactorily maintained.

DISTRICT MEETINGS.

Three District Meetings have been held: at Portland, on August 26, 1899; at Merthyr, on September 23, 1899; and at Carlisle, on May 26, 1900.

THE ROLL OF THE ASSOCIATION.

During the financial year ended April 30 last, 83 New Members, consisting of 58 Ordinary Members and 25 Graduates, have joined the Association. Seven Members have resigned.

Thirteen names have been written off, and the Council record with regret the deaths of G. R. Andrews, C. G. Bennett, R. Brierley, R. Davies, R. A. Gray, T. L. Lewis, T. Mallinson, T. C. Thorburn and H. Woods. In addition to these, the Council have also to record the death of Mr. Edward Pritchard, Past-President, who was one of the founders of the Association. For many years the Hon. Secretary of the Midland District, and latterly an examiner, his long service in the Association was ever marked with the keenest interest in its usefulness, welfare and success.

The number on the Roll of the Association at the close of the year was 9 Honorary Members, 793 Ordinary Members, and 128 Graduates, making a total of 930, being an addition of 6·2 per cent. on the numbers of the preceding year.

The Council have transferred Messrs. S. P. Andrews, R. J. Angel, A. J. Dickinson, W. D. Harding, J. W. Liversedge, R. Oakden, F. H. Parr, A. J. Price and J. A. Wright from the class of Graduates to that of Members, these gentlemen having been elected to appointments qualifying them for this class under the Articles of Association.

The Finances.

The audited Balance-Sheet and Statement of Accounts which accompany this Report show a balance in hand on April 30 last of 87*l.* 5*s.* 10*d.*

The expenses for the year have been abnormally heavy in the production of the year's 'Proceedings,' together with the preparation and publication of the quinquennial Index. The Council feel, however, that the Members will agree that the additional expense in this direction is warranted by the enhanced value of the Proceedings as a work of reference. The Statement of assets and liabilities shows the financial position of the Association to be sound.

The Examinations.

Since the last Report three examinations have been held—one at Liverpool, on October 6 and 7, 1899, when 22 candidates presented themselves for examination. Of these, 13 satisfied the examiners and were granted their certi-

ficates. The examiners were Messrs. Angell, Eayrs, Fowler and Yabbicom.

The second examination was held in London, on March 30 and 31, 1900, when 23 candidates presented themselves, of whom 15 satisfied the examiners and were granted their certificates. The examiners were Messrs. Eayrs, Fowler, Lemon and Pritchard.

The third examination was also held in London, on April 6 and 7, 1900, at which 24 candidates presented themselves, of whom 16 satisfied the examiners, and were granted their certificates. The examiners were Messrs. Crimp, Jones, Lobley and May.

The Council are pleased to record the increasing recognition by the authorities of these examinations, one of the latest examples being the acceptance of the certificate of the Association by the Local Government Board of Ireland as one of the qualifications for the post of Assistant County Surveyor.

The New Council.

The ballot lists having been duly issued, the Scrutineers reported the result of the voting as follows:—

President—Mr. Chas. H. Lowe.

Vice-Presidents—Messrs. E. G. Mawbey, W. Weaver and T. H. Yabbicom.

Ordinary Members of Council—Messrs. J. P. Barber, W. N. Blair, A. E. Collins, A. Creer, A. T. Davis, A. D. Greatorex, E. P. Hooley, A. B. MacDonald, J. Paton, S. S. Platt, J. Price and C. F. Wike.

Honorary Treasurer—Mr. Lewis Angell.

Honorary Secretary—Mr. Charles Jones.

Superannuation.

This matter has received the continued attention of the Council, delegates having been sent to a conference called by the Municipal Officers' Association on the subject, and a contribution of 10*l.* 10*s.*, in addition to the delegates' fees, was paid in aid of the expenses to be incurred in connection with the promotion of the Bill, which has been again introduced into the House.

In view of an intimation from the Local Government Board that their attitude towards the measure would depend upon the support given to it by the local authorities of the country, it behoves the Members of the Association to exert themselves in order to obtain the support of their respective authorities and Members of Parliament for the Bill.

The Orphan Fund.

The Fund that was inaugurated in 1898 for the benefit of orphans of Municipal Engineers has advanced a stage during the present year, the control of the fund having been tentatively taken over by the Association and a provisional committee appointed pending the appointment of the permanent committee.

The rules and regulations for the governing of the Institution have been drafted, and, together with other business, have been submitted for consideration by the subscribers at the first Annual Meeting, held immediately before this Annual Meeting of the Association, in July 1900 (see Appendix). The committee and officials to administer the funds were permanently appointed at this meeting, and it is hoped that the endeavours of those initiating the fund will be readily and generously seconded by the Members of the Association, and thereby in some measure mitigate the pain and trouble ensuing in some families by the loss of the husband and father.

The Case of Mr. Lewis Angell.

The circumstances attending this case and the principles involved therein induced the Council to take every possible step which could be taken towards the protection of its Members, and accordingly the particulars were laid before the Solicitors of the Association, who, after having gone very carefully into the whole case, stated that, taking the law as it at present stands, they were unfortunately unable to recommend the Council to take any steps in the matter.

The Council took upon themselves, however, to voice the Association's view of the harsh and unmerited treatment that Mr. Angell had received at the hands of his Corporation, and sent a strong protest to this effect to the West Ham Corpora-

tion and to the Local Government Board, whilst the sympathy of the Association was respectfully conveyed to Mr. Lewis Angell.

The New Form of Application.

Your Council, in their consideration of applications for membership, have found it necessary to issue a new form of application, resulting in the obtaining of much fuller information as to the candidate's professional training and qualifications than heretofore.

The Council would particularly urge Members, when signing forms, to read carefully the qualifying description as given by the candidate, and in case of doubt to verify the same before appending their signatures.

In this direction the Council recognise the indebtedness of the Association to the Honorary District Secretaries, upon whom so much of the labour involved in the collection and verification of information falls.

Chas. Jones, *Hon. Sec.*
Thomas Cole, *Secretary.*

On the motion of the President, seconded by Mr. J. T. Eayrs, the Report was received and adopted.

On the motion of Mr. E. G. Mawbey, seconded by Mr. A. D. Greatorex, Mr. J. P. Dalton was elected Honorary Secretary for the Yorkshire District, *pro tem.*, and the other District Secretaries were re-elected pending meetings in their various Districts.

Messrs. W. H. Savage of East Ham and S. Stallard of Croydon were re-elected Auditors for the ensuing year.

Mr. H. J. Clarson of Tamworth, Mr. E. J. Silcock of Leeds, and Mr. F. S. Yates of Waterloo, were elected Scrutineers for the ensuing year.

The President then presented Mr. A. D. Greatorex with the Association's premium of five pounds in books, for his paper on "Electric Traction" read at the Annual Meeting at Cardiff last year. Mr. Harpur remarked that those who were

present on that occasion knew the interest with which it was received, and the valuable discussion it evoked, and were able to recognise that the amount of labour expended upon it was very great.

Mr. Greatorex having briefly replied,

Mr. Harpur introduced his successor Mr. Charles H. Lowe, and vacated the Chair in his favour.

Mr. T. H. Yabbicom proposed and Mr. F. J. C. May seconded a hearty vote of thanks to the retiring President for his services to the Association during the past year. He thought that the harmony that had always prevailed in the proceedings, both at the District Meetings and at the Council Meetings, was largely due to the President's courteous manner of carrying out his work.

Mr. Harpur acknowledged the vote.

Mr. Lowe then read his Inaugural Address,* a hearty vote of thanks for which was proposed by Mr. C. Jones, seconded by Mr. Mawbey, and carried unanimously.

Mr. J. P. Barber then moved the following resolution :—

"That it be referred to the Council to consider and report upon the desirability of altering the Articles of Association and Bye-Laws for the undermentioned purposes:

"I. The admission to the Association of Assistant Surveyors and the principal Engineering Assistants to Municipal and County Engineers.

"II. The making of alterations in, and additions to, the Bye-Laws, by Resolution of the Members at an Annual General Meeting, on the recommendation of the Council.

"III. Limiting the period during which a Past-President shall be a Member of the Council.

"IV. Reducing the number of names nominated by the Council for Vice-Presidents."

The several sections were duly seconded and discussed, and the motion was carried unanimously.

* This Address and the Papers read at the Meeting will be found at the end of the volume.

The following papers were read and discussed :—

"Conditions Necessary for Successful Purification of Sewage by Land Treatment," by H. Royle. "The Last Twelve Months' Experience in the Bacterial Treatment of Sewage," by G. D. Thudichum. "The Rate of Rainfall," by J. P. Dalton. "The proposed Manchester and Liverpool Electric Railway," by Sir Wm. Preece. "Light Railways from a County Surveyor's Point of View," by H. T. Wakelam. "Sewage Pumping Machinery at Richmond," by W. Fairley.

Votes of thanks to the several Authors of the papers were passed unanimously.

RECEIPTS.	£	s.	d.
To Balance at Bank, May 1, 1899	209	8	5
„ Entrance Fees	53	11	0
„ Subscriptions	714	10	3
„ New Graduates	13	13	0
„ Subscriptions in advance	14	14	0
„ Arrears	28	17	6
„ Sale of 'Proceedings'	25	10	4
„ Examination Fees	280	18	0
„ Interest on Investments	29	3	8
£	1370	6	2

STATEMENT OF ASSETS

LIABILITIES.	£	s.	d.
To Estimated Liability on Vol. XXVI.	40	0	0
„ Sundry Printing, Stationery, &c.	25	0	0
„ Reporting	8	8	0
„ Sundry Creditors	9	4	6
„ Balance	1097	5	10
£	1179	18	4

Examined and found correct, this

EXPENDITURE.	£ s. d.	£ s. d.
By Reports of Meetings	..	33 12 0
„ Examiners' Fees and Expenses	..	150 17 10
„ Examination Expenses	..	19 6 8
„ Hire of Rooms	..	8 14 0
„ Auditors' Expenses	..	2 2 0
„ Scrutineers' Expenses	..	4 18 0
„ Meetings, Expenses	..	14 2 9
„ Printing and Stationery	..	53 19 1
„ Messrs. Clowes, Vol. XXV., Index, and other Printing	..	401 14 2
„ Messrs. Sprague, Illustrations	..	33 2 8
„ Hire of Telephone	..	17 0 0
„ Secretary, Salary and Rent	..	300 0 0
„ Allowance for Assistant	..	60 0 0
„ Indexing Volumes	..	25 0 0
„ Contribution to Expenses of Joint Examination Board	..	5 0 0
„ Loan to Joint Examination Board	..	15 0 0
„ Conference, Superannuation: Delegate's Fee ..	..	3 3 0
„ Contribution to Expenses of ditto	..	10 10 0
„ Messrs Sharpe, Parker, Pritchard & Co.	..	2 2 0
„ Travelling Expenses	..	9 19 1
„ Banker's Charges	..	1 15 1
„ Petty Cash—		
Balance due from last account	13 5 9	
Postages	32 18 4	
General	17 18 4	
Balance in hand	6 7 7	
		70 10 0
„ Postage of Circulars, &c.	..	40 12 0
„ Balance at Bank, May 1, 1900	..	87 5 10
	£	1370 6 2

AND LIABILITIES.

ASSETS.	£ s. d.	£ s. d.
By Balance at Bank, May 1, 1900	..	87 5 10
„ £490 Southampton Corporation Stock at 95 ..	..	465 10 0
„ £260 7s. 4d. India 2½ per cent. Stock at 89 ..	..	231 15 0
„ £261 14s. 7d. London County Council Stock at 87	..	227 15 0
„ Subscriptions in Arrear	161 16 0	
Less 50 per cent. bad	80 18 0	80 18 0
„ 'Proceedings' in Stock	234 18 0	
Less 70 per cent.	176 3 6	58 14 6
„ Office Furniture	..	28 0 0
	£	1179 18 4

24th day of May, 1900.

W. H. Savage, Sidney Stallard } *Auditors.*

Lewis Angell, *Treasurer.*
Thomas Cole, *Secretary.*

DISTRICT MEETING AT PORTLAND.

August 26, 1899.

Held at the Royal Hotel, Weymouth.

W. Harpur, M. Inst. C.E., President, *in the Chair.*

Mr. J. Lano, Chairman of the Portland District Council, extended to the President and the Members of the Association a hearty welcome to Portland. Within his time the profession of the civil engineer had overcome formidable natural difficulties, rivers had been bridged and canals had been cut, whereby places which were formerly wide apart, so far as communication was concerned, had been brought into close connection. That change had been brought about by the skill and science of engineering. He could say that it was in great part due to Mr. Elford's enthusiasm that they were encouraged to carry out the Waterworks shortly to be visited.

The President, in acknowledgment, thanked the Chairman and Council very heartily for their very kind welcome to Portland. The Association was one which aimed at diffusing information amongst its Members, and the meetings are to the advantage of the town in which they are held. The President referred to the difficulties Mr. Elford had experienced in Portland, as described in the paper, and said that if any advice could be given by any Member present, or by any other Member of the Association, it would be given in the most willing and ready manner.

Mr. T. H. Yabbicom proposed the re-election of Mr. Hall as Honorary Secretary for the Western Counties District. Mr. Hall had had a considerable number of years' experience of

the work as Honorary Secretary of this district, and had carried out his duties to the satisfaction of the Association.

This was seconded by Mr. H. Nettleton, and carried unanimously.

Mr. J. Hall, in acknowledgment, thanked the Members, and expressed the hope that more meetings might be held in the Western District than had recently been the case.

THE NEW PORTLAND WATER AND MAIN DRAINAGE WORKS.

By ERNEST J. ELFORD, Surveyor to the Urban District Council of Portland.

Before describing the above works, it may perhaps be of interest to the Members of the Association if a brief reference is made to the general characteristics of the Island of Portland. In reality, Portland is now a peninsula, although it is probable that at one time it was entirely surrounded by water. It is connected with the main-land by the famous Chesil Beach, which extends from the north end of Portland to a distance of about 16 miles before it joins the main-land. The average width of this beach is about 180 yards, and its height varies from 40 to 60 feet. The pebbles of which it is composed are at the Portland end from 1 to 6 inches in diameter, gradually becoming smaller as the main-land is approached, until they are little larger than coarse sand.

They vary in composition, but the majority consist of quartzite. During the past three years the Author has been using large quantities of these pebbles for road-making; for which purpose the larger pebbles were selected and broken by machine to pass through a 2-inch ring. The quartzite is exceedingly hard and tough, and after being broken forms good, clean roads, and wears almost as well as granite. A small quantity of hard limestone from the Purbeck beds on the island is mixed with the pebbles, and supplies an excellent binding material, even in very dry weather. But this is by the way.

The island is wedge-shaped, and lies practically north and

south, its base facing the north. It is slightly over 4 miles in length, about 1½ mile in width at its broadest part, and over 9 miles in circumference. Its height at the northern end is over 500 feet above Ordnance datum, the surface sloping from this point to the Bill, where it is not more than 20 feet above Ordnance datum. The total area of the island is about 3000 acres.

Many causes have conduced to bring Portland into prominence. It is known principally as being the home of the finest British building-stone, and as containing one of Her Majesty's most famous convict establishments; whilst its magnificent harbour has brought it world-wide celebrity, and latterly, as the headquarters of the Channel Fleet, the island has been brought into special prominence in the naval world. Up to the year 1837, the only means of approach from the main-land was by ferry. In that year the Portland ferry bridge was built, and subsequently, in the year 1865, the Weymouth and Portland Railway was constructed. Since the latter date the district has made rapid progress. Before the introduction of the railway, the inhabitants of the island were very jealous of strangers, whom they distinguished by the title of "Kimberlins," but this feeling is rapidly dying out. The small town of Fortune's Well is situated on the northern slope, and on the top of the island is the township of Easton and the villages of Weston and Southwell. The convict prison was constructed in 1847, and was originally intended to afford temporary accommodation for the prisoners engaged upon the construction of the breakwater. Since that time extensive fortifications have been erected, and the convicts have remained to assist in the construction of these and other works; in this manner the prison has become a permanent institution.

Large quantities of stone are quarried by the prisoners for Government works in other parts of the country, and a considerable quantity of work is done in the foundry and the various workshops for Admiralty, Army and Prison purposes. The number of prisoners varies from 800 to 1400. The stone industry will be referred to in the Author's "Notes on Portland Stone." The first stone of the famous breakwater was laid by H.R.H. Prince Albert, in July 1849; and, twenty-three years later, H.R.H. the Prince of Wales carried out the ceremony of laying the last stone, which marked the completion of the structure, on August 10, 1872. The breakwater is divided

into two sections, with an opening between them of about 400 feet, giving a depth of water at low tide of about 45 feet. The first section is about 1800 feet in length, the outer section being about 7500 feet long. The breakwater is constructed of heavy masonry built upon a foundation of huge blocks of rock irregularly deposited on the bed of the sea. More than five and a half million tons of stone were used, and the total cost amounted to about one million sterling.

At the outer end of each section is a circular fort constructed of granite. The smaller fort, situate at the end of the first section, contains eight 64-pound guns. The fort at the end of the outer section is of very massive proportions. It is armed with sixteen 100-pound and other guns, to the total number of sixty, and has accommodation for 150 men. A second breakwater is now in course of construction, and this, with the original structure, will enclose a deep-water harbour about four square miles in area, having a tenacious anchorage of Kimmeridge clay. The island is heavily fortified, and is considered to be practically impregnable when efficiently garrisoned.

The total population of the district in 1891 numbered slightly over 9000. At the present time it is estimated that the civil population only is that number, to which must be added the military, prison and naval population, varying in number from 4000 to 12,000, so that at times the total exceeds 20,000.

Portland is a Royal manor, and many quaint laws and customs which have long since died out in other parts of the country still exist within its borders. Most of the inhabitants are freeholders, the land in those cases where the head of the family dies intestate, being equally divided between the children. The method of conveying the land is by church-gift, in the presence of two tenants of the manor, the whole process costing but a few shillings.

The island is one parish, and is in the diocese of Salisbury.

After this very brief description of the island itself, the Author must proceed to speak of the

Waterworks.

For many years the water question has been a cause of considerable worry to the Portland local authorities. As far back as 1868 this matter was under consideration, and a pro-

posal was then made to form a water company. All that was done, however, up to 1871, was the sinking of two public wells in the Tophill portion of the district, and the construction of storage tanks in connection with the various small springs in the Underhill district. In 1871 the Local Board, after persistent pressure from the Government departments, pledged themselves to provide a pure and adequate water supply, and an efficient system of drainage for the island. The same year the board offered two premiums of 40*l.* and 20*l.* for the best schemes for the drainage and water supply of their district. These premiums were awarded, but neither of the schemes were carried out; in fact, although the matter was continually under discussion, nothing further was done until 1889. In that year the Local Board again expressed their intention of carrying out a proper and efficient water supply scheme, and from that time the authorities have taken the matter in hand most earnestly.

Several schemes were suggested, and it was ultimately decided, on the recommendation of some of the most eminent hydro-geologists, to sink a well on the island near the village of Southwell, at a point situated about 1¼ mile from the Bill, 800 yards from the East Cliff, and 600 yards from the West Cliff. The work was commenced in 1891, and the shaft was sunk to a depth of 206 feet below the surface, the bottom being about 31 feet below Ordnance datum, and 38 feet below high-water mark spring tides.

The water was analysed from time to time with fairly satisfactory results. Subsequently adits were driven at about 10 feet above the bottom of the well in an E.N.E. and W.N.W. direction, the former to a distance of 140 feet and the latter to a distance of 168 feet.

On the 17th May, 1895 (the date upon which the Author entered upon his duties at Portland), a period of thirty-five days' continuous pumping from the well to test the yield of water was completed, the average yield during that period being at the rate of 116,000 gallons per twenty-four hours.

On the same day samples of water were taken in the presence of the Water Committee, and forwarded to Dr. Frankland, analytical chemist to the Local Government Board, for examination. His report was received on June 3, and was as follows:—

"THE YEWS, REIGATE,
June 2, 1895.

"Dear Sir,—Herewith I enclose results of analysis of a sample of water sent here for examination by the Portland Urban Sanitary Authority.

"This sample contains a large proportion of sea water, mixed with land water containing a considerable amount of decomposed sewage. Although the residual quantity of animal organic matter still left in the water is but small, I am of opinion that it is not fit for human consumption, and it is too hard to be economically used for washing.

"I am, Sir,
"Yours very truly,
"E. FRANKLAND.

"RESULTS OF ANALYSIS IN PARTS PER 100,000. *May* 20, 1895.

Number of Sample, 9405. *Portland Water.*

Organic carbon		·082
Organic nitrogen		·000
Ammonia		·000
Nitrogen as nitrates and nitrites		·348
Total combined nitrogen		·000
Chlorine		137·000
Hardness:		
Temporary	15·000	
Permanent	88·000	
		103·000
Total solid matters		333·340

ERNEST J. ELFORD, ESQ., *Water Engineer.*"

Needless to say, the result of the analysis created great disappointment and surprise, but the council decided to have other samples taken, and, in accordance with this decision, three samples were obtained, one of which was sent to Dr. Frankland, the two remaining samples being sent to other chemists. The results confirmed the report of Dr. Frankland on the first sample, but as the water had been allowed to regain its normal level and to remain undisturbed for some time, the quantity of saline matter had considerably decreased. This result appears to indicate that the advent of sea water into the well was due to the continuous pumping, so reducing the pressure of the land water as to cause a back flow of water from the sea. It

is quite possible, therefore, that a supply of water up to a certain quantity might be taken from the well without incurring any risk of contamination by sea water, but this quantity would necessarily be very limited. The contamination by sewage could not, however, be ignored, and the total yield of the well, even during April and May, when the springs are at their highest, was quite insufficient to supply the needs of the district, the Local Government Board requiring the council to provide a supply of 200,000 gallons per day.

As the works had already cost about 7500*l.*, the council were placed in a very serious position; but in spite of the difficulties surrounding the situation, they realised it to be their duty to provide the district with an efficient supply of water, and they decided to fulfil their obligations whatever the cost might be. As before suggested, a limited supply of water might have been derived from the Southwell shaft, but the water could never have been above suspicion, and the Author strongly recommended the council to abandon the scheme. This recommendation was adopted, but at the same time the council felt keenly the loss of the large expenditure of labour and money upon the works which had thus proved such an unfortunate venture. Instructions were given to the Author to immediately prepare a report dealing with the whole question. In accordance with these instructions, he presented an exhaustive report to the council, in October 1895, in which he recommended that no further attempt be made to obtain a supply of water from the island, where, in his opinion, it was impossible, owing to the limited area of gathering ground available, the imperfect sanitary condition of the district, and the open nature of the strata, to obtain an adequate and pure supply.

Three schemes were dealt with in this report. The first was a scheme that had previously been suggested, and from time to time had been considered and had found some favour. The suggestion was that a supply of water in bulk should be obtained from the Weymouth Water Company and distributed by the council. This scheme was open to very serious objection, as the Weymouth company would not supply the water at a less rate than sixpence per thousand gallons, which, with a consumption of 200,000 gallons per day, would mean a total annual payment by the council of over 1800*l.* Besides this, the water could not be supplied to the district by gravitation, but

would require to be pumped to an additional height of about 300 feet, necessitating an increased outlay. The capital cost of the pumping plant, buildings, reservoir and distributing works would cause an annual expenditure covering repayment of principal and interest of about 900*l.*, and to this would have to be added the cost of the water, 1800*l.*, and the working expenses, causing the expense to the district to exceed 3000*l.* per annum. Other causes militated against the adoption of this scheme. The supply of water would necessarily be uncertain, as the company would be required to give precedence to the wants of their own district; and the annual charges for water would be in perpetuity, and would increase rather than diminish as time went on; and the council might find at some future time that they were obliged to adopt some other and totally different scheme.

The Author therefore advised the council not to adopt any scheme which depended for its supply upon the works of the Weymouth Water Company.

After referring to the geological features of the neighbourhood in relation to the question of water supply, and of which he had made a careful examination, the Author expressed the opinion that the council must obtain their supply from the large area of chalk to the north of Weymouth. As the result of inquiries he had made, it appeared to the Author that the most favourable point for obtaining such a supply would be in the neighbourhood of Portesham. Fearing that the council, after their disastrous experience at Southwell, would be very loth to venture upon the construction of another well, the Author presented two alternative schemes. The first scheme included a proposal to obtain a supply from a deep well to be sunk in the chalk; the suggested source of supply in the second scheme being the Portesham spring. The council decided to adopt the last mentioned, and approached Lord Ilchester with a view to purchasing his interest in the spring. His Lordship, however, refused to surrender his water rights on any terms whatever.

It was then too late in the year to proceed with a Bill for obtaining Parliamentary powers to take compulsorily the water required, and before further steps could be taken the council were approached by Captain Gould, R.E., a large landowner at Upwey. He offered to sink a well and obtain a

supply of water sufficient both as regards quantity and quality to meet the requirements of the Local Government Board, on his estate at Upwey, the council to enter into a provisional agreement with him to purchase the well and certain land for a pumping station, reservoir, etc., and also the Upwey Mill, for a sum of 3,500*l.* In addition, he agreed that should the council purchase the well so constructed, he would not sink any other well upon his estate or do any other acts which would or might be detrimental to the supply of water from such well. This offer was accepted, and the provisional agreement entered into.

The site selected by Captain Gould is situated at a distance of about 100 yards from the famous Upwey "Wishing Well," which is the source of the River Wey. The Wishing Well is one of the finest springs in the county, and its total yield has at times exceeded ten million gallons a day.

Copies of the agreement, and plans showing the position of the proposed well and its surroundings, were sent to the Local Government Board before sinking operations were commenced.

The well was duly sunk by Captain Gould, and in February 1896 water was found at a depth of about 20 feet below the surface. On March 10 and 11 a test of twenty-four hours' continuous pumping was carried out, and resulted in a total yield exceeding 400,000 gallons. Thereupon the council decided to take over the well, and, with Captain Gould's consent, to continue the sinking to a further depth of 6 feet. This additional sinking was completed on April 8, the yield at that time being at the rate of 750,000 gallons in the twenty-four hours.

A sample of the water was then sent to Dr. Frankland, the result of his analysis being that he pronounced the water to be of excellent quality and above the average of chalk waters.

The Local Government Board, who were informed from time to time as to what was being done, had a copy of Dr. Frankland's report sent to them. The council suggested that they should test the quantity of the water by continuous pumping during a period of thirty days. The Local Government Board concurred in this suggestion, and gave detailed instructions as to the method to be adopted, and as to the kind of meter, etc., they would like to be used for measuring and recording the quantity of water pumped. Everything was duly prepared in accordance with these instructions, and the council requested

the Board to send one of their engineering inspectors to see that the arrangements made met with their approval. The inspector visited the site of the well on June 27. He required a few slight alterations to be made, and these having been effected the test pumping was commenced on the following day. On July 2 a letter was received from the Local Government Board requesting the council to at once discontinue the test pumping and all other work connected with the well, and informing them that the Board would not sanction the borrowing of any money for the construction of waterworks to be supplied from this well, "because of the possibility of contamination from the village churchyard." This churchyard has been practically in disuse for many years. It is situated at a distance of about 100 yards from the site of the well, and on the opposite side of a valley through which a stream of water flows, and on a bed of practically impervious soil about 10 feet thick. The council felt that it would no doubt cause great delay and would probably be useless to oppose the Local Government Board, and they therefore immediately entered into negotiations with Captain Gould to acquire another site upon which to sink a well. Ultimately a fresh site was agreed upon, and sanctioned by the Local Government Board after three visits had been made by their inspectors. A loan of 500*l.* was obtained, and a contract entered into with Messrs. B. Cooke & Co., of London, for sinking the well and subsequently carrying out thirty days' test pumping. On the same day as that upon which the council sealed this contract with Messrs. Cooke & Co., notices were published in the local press of the intention of the Weymouth Water Company to apply to Parliament in the ensuing session for powers to supply certain portions of Portland, including the Government establishments. It appeared by the terms of these notices that the company were seeking powers to supply the low-lying and best paying portions of the island, leaving the council with the obligation to supply the high-level districts, where the population is scattered and the revenue would be exceedingly small.

The people of Portland, after the efforts they had made and the money they had spent in endeavouring to obtain a supply of water for the Government establishments and the inhabitants of the island, keenly resented this effort of a local monopoly to take from them their powers and privileges, and

render ineffective the endeavours they were making to put into operation the powers the legislature had conferred upon them.

The council unanimously decided to use every effort in opposition to the proposals of the Weymouth company, and subsequently, at a public meeting of ratepayers, this decision of the council was ratified.

In the meantime the well at Upwey was sunk to a depth of 100 feet, and a 12-inch borehole to a further depth of 70 feet. The test pumping was then proceeded with, and resulted in an average yield of about 280,000 gallons per day, being 80,000 gallons per day in excess of the quantity required by the Local Government Board. A sample of the water was sent to Dr. Frankland, who reported as follows:—

"Water Analysis Laboratory,
"The Yews, Reigate,
"*18th March*, 1897.

"*Upwey Water.*

"Dear Sir,—Herewith I enclose results of analysis of the sample of this water, which you sent here for examination.

"This water possesses an extremely high degree of organic purity, and is of the most excellent quality for dietetic use.

"It is of medium hardness, but becomes very soft on boiling.

"The sample as received by me was turbid, but this no doubt is due to the operations still going on in the well.

"I am,
"Yours very truly,
"E. Frankland.

"Results of Analysis expressed in Parts per 100,000.

Number of Sample, 10,200. *Water from Shaft at Upwey.* *March* 4, 1897.

Organic carbon		·029
Organic nitrogen		·004
Ammonia		·000
Nitrogen as nitrates and nitrites		·484
Total combined nitrogen		·488
Chlorine		2·400
Hardness:		
Temporary	14·900	
Permanent	3·100	
		18·000
Total solid matters		21·405

Ernest J. Elford, Esq., C.E."

The company's Bill passed its second reading in the House of Commons and was referred to committee.

The Author gave evidence before the committee in opposition to the Bill; Messrs. Baldwin Latham and H. Rofe, engineers, and Mr. C. E. Hawkins, of H.M. Geological Survey, corroborating his evidence.

The committee stage lasted about three weeks. Unfortunately the Admiralty supported the company, and in the end a compromise was effected under which the company obtained powers to supply the Admiralty with a limited quantity of water for a period of fifteen years; the council to have the right to lay the mains required for this purpose, which would lie within their own district, and also the right to take the water from the company at the boundary of their district, and themselves supply it to the Admiralty. The council were successful, therefore, in their endeavour to keep the company outside the island, but their effort to keep out the company's water entirely was only rewarded with partial success.

The Author then proceeded to prepare his scheme in detail, and application was made to the Local Government Board for sanction to raise a loan of 37,500*l.*, to construct the necessary works. After the usual local inquiry and the customary months of delay, with which all who have anything to do with the "Board above" are familiar, sanction to the loan was received. In the meantime the council had laid the pipe for the Admiralty supply from the Weymouth company, and also a considerable length of the 10-inch delivery main from Upwey.

Tenders were invited for the completion of the works, and that of Messrs. Bostel, Sons & Peattie, of London, amounting to 28,500*l.*, was accepted, and a contract entered into. The works were commenced on April 7 last year, and included the sinking of the well to an additional depth of 66 feet, and the driving of headings; the construction of the pumping station buildings, and provision and installation of the machinery and boilers; the construction of a tall chimney shaft and of the service reservoir, and the provision and laying of about 20 miles of cast-iron pipes, etc.

The period allowed for the completion of the works was sixty weeks, which terminated on June 1 last.

Additional time allowances amounting to thirteen days have been made by the Author, extending the time of completion to

June 14. The reservoir was completed by the end of January, and the 10-inch main delivery pipe from Upwey to Portland by the beginning of March. The laying of the distributing pipes throughout the island proceeded somewhat slowly, owing in great measure to delay in the delivery of the pipes and difficulty in obtaining labour. At the time of writing about two miles of these pipes have still to be laid.

The greatest difficulties have arisen in connection with the work of sinking the well. After signing the contract, the contractors pointed out to the Author that they were inexperienced in work of this kind, and as they did not possess the necessary plant and appliances, they applied for permission to sublet this portion of the work to a firm of well sinkers. The specification stipulated that the contractors should provide and fix at and in the well temporary pumping plant capable of raising continuously not less than 32,000 gallons of water per hour, and that they should provide the labour, fuel, oil, etc., necessary for working such plant. After making inquiries with reference to the firm suggested, the Author gave his sanction to the proposal of the contractors, the understanding being that the sub-contractors would employ special pumping plant, having no working parts situated in the well with the exception of the pump rods, buckets and valves.

In the Author's absence, however, a large Cornish sinking pump was placed in the well, and the steam, delivery and exhaust pipes were fixed in position.

The sub-contractors' excuse was that they found it impossible to obtain one of the special pumps of sufficient size to comply with the requirements of the specification in less than four months, and consequently to avoid this delay they intended to use the Cornish sinking pump in conjunction with a pulsometer. This change in the pumping plant has resulted in many months of delay and heavy financial loss to the contractors. The water rises in the well to within 50 feet of the surface, so that at the commencement of the additional sinking it was not possible to fix the pump at a greater depth than 52 feet above the bottom of the well. It was therefore necessary to pump the water into a tank about 30 feet from the bottom by means of the pulsometer before the large pump could deal with it. The pump was started on June 16, and the sinking commenced. On the 25th the pump had to be

stopped for repairs. It started work again on the 28th, and broke down the same evening, being under repair until the following day, when it again commenced work. Another break-down occurred on the 7th July, and no sinking could be done until four days later. The well work proceeded in this manner for several months. The pumps had to be lowered from time to time, as the depth of the shaft increased. This caused further delays, as stoppages were continually occurring. Other difficulties also presented themselves. Either the pump broke down, or a larger pulsometer was required, or the boiler had to be cleaned out, or the stoker fell asleep and allowed the steam to go down; and on the occurrence of either of these mishaps the 9-inch delivery pipe and the steam and exhaust pipes had to be disconnected, and the pump, weighing about 3 tons, raised above the surface of the water. After the necessary repairs or other work had been effected, the pipe joints had to be remade and the pump gradually lowered.

The process of lowering the pump whilst it was at work was attended by considerable risk, as the great vibration frequently caused the joints to break. For this reason many attempts were made to start the pump under water, the steam being turned on until the temperature of the water in the shaft had been raised enough to allow sufficient uncondensed steam to enter the steam cylinder of the pump to start it. This occupied a great amount of time, and it frequently happened that before the pump could clear itself one of the joints was blown, or something else happened which made it necessary to raise it above the water level. On one occasion the Author found that the temperature of the water in the well had been raised to 114° F. The sub-contractors complained that the amount of steam supplied by the 30 horse-power, semi-portable boiler was insufficient, and considerable delay was occasioned before a second boiler of a similar kind and capacity could be obtained. Unfortunately the provision of a second boiler did not very much improve matters, and the work dragged on until the end of November last, when the council held a meeting at Upwey, and informed the contractors that an alteration must be made, and that unless the work was considerably accelerated they would have no alternative but to take it out of their hands and complete it themselves in accordance with the terms of the contract.

For a little time matters improved somewhat, but it was not

until March that the well had been sunk to the full depth; the sinking of the 66 feet included in the contract having taken nine months, or an average of 7⅓ feet per month.

The Author had from time to time endeavoured to bring pressure to bear upon the contractors with the object of inducing them to get rid of the sub-contractors, but owing, as he understood, to the terms of the sub-contract, this end could not be secured. As soon, however, as the shaft had been sunk to its proper depth, they determined at any cost to terminate the contract. During the four months the two boilers were at work they had consumed on an average over 50 tons of coal a week, and as the contractors were required to provide the sub-contractors with steam, they at last came to the conclusion that it was absolutely necessary to adopt more economical arrangements. They therefore entered into negotiations with the sub-contractors, and ultimately arranged to buy them out. Immediately this decision was arrived at, the contractors obtained and fixed at the well the temporary pumping plant at present at work there. This plant consisted of two deep well pumps each having a working barrel twelve inches in diameter. The pump rods are connected to a pair of rocking bobs attached to heavy girders placed across the well, and are driven by an iron shaft which is actuated by a crank shaft, driven by heavy intermediate gearing.

This gearing is driven by a belt from a 14 horse-power portable engine, the coal consumption averaging about 6 tons per week. The pumps have worked admirably and without a hitch since they were first started, over four months ago, and by the beginning of July nearly 200 feet of the headings had been driven out of the total length of 900 feet provided for in the specification. At the completion of the additional sinking the total yield amounted to about 340,000 gallons a day. The total yield of the headings at the time of writing is 140,000 gallons, but as the yield of the shaft has decreased (owing to the dry season) to about 260,000 gallons, the total yield does not exceed about 400,000 gallons a day.

The quantity of water which the Local Government Board requires to be provided is 200,000 gallons per day, but the Author is of opinion that the council, to be in a position to supply the present and probable future population of their district, and the needs of the Admiralty and other Government

departments, allowing also a perfectly safe margin for contingencies, should, if possible, make provision for a supply of about 450,000 gallons per day.

It is probable, however, that the consumption will be much lower than this, as a large proportion of the houses in the district are provided with rain-water cisterns, and no doubt the residents will continue to use this water for most purposes other than dietetic. In addition, several of the existing springs in the island will probably be utilised for sewer flushing, etc., and both the Admiralty and the prison have works from which they draw considerable quantities of water for flushing and slopping purposes, and these sources will no doubt continue to supply water for the purposes mentioned.

The contract provides for the obtaining of a total supply of 750,000 gallons a day, so as to allow a large margin should the well have been completed during the wet season. As a matter of fact, however, the work was carried on during the driest period of a year which was exceptionally free of rain, succeeding two very dry seasons, and after many months of continuous pumping. The present conditions are probably therefore as unfavourable as any likely to be met with in the future.

Of the 200 feet of headings already driven, about 60 feet consist of two short experimental headings which yield practically nothing.

The well shaft, which is circular and eight feet in diameter, has been sunk through a portion of the middle chalk, in which thin layers of flints were found, into the top portion of the lower chalk, which is practically free from flints. The heading is being driven at a depth of 158 feet from the surface, and in a south-west direction towards the great Ridgeway Fault.

This fault extends practically due east and west of the well, and to a distance of about six miles in each direction. The shaft is situated to the north of the fault, and at a distance of about 500 feet from it. The water, as it flows southward underground, is arrested by the impermeable Kimmeridge Clay, on the south side of the fault, so that it rises in the chalk until it overflows into the Portland and Purbeck beds, where these are present—as at Upwey, where it supplies the Wishing Well; or into the open, where they are not present—as at Portesham and Sutton, in the latter instance forming the source of supply of the Weymouth Water Company.

The chalk at the site of the well has been found exceedingly hard, and explosives have had to be used during the whole of the operations. Several kinds of explosives were experimented with, including tonite, dynamite and gelanite, but neither of these has given such satisfactory results as ammonite, which has been exclusively used for many months. One excellent quality possessed by this explosive is the perfect safety with which it may be handled, as it will not explode except when used in conjunction with a powerful detonator. The chalk is of so hard and compact a character that it will be unnecessary to line the well except for a depth of about 10 feet from the top. This upper portion will be lined with concrete faced with white glazed bricks. The concrete will be of sufficient thickness and strength to form a foundation for the engines.

Recording apparatus, for continuously recording the water level in the well, will be provided in the engine house.

The pumping station includes an engine house 21 feet by 36 feet, boiler house 19 feet by 35 feet, coal store, workshop, and a superintendent's house. The buildings are of red Wellington bricks, with Portland stone dressings.

The boiler shaft is 72 feet in height, the first 25 feet being square and the remaining portion circular, being surmounted by a cast-iron cap and lightning conductor. A fire-brick lining is carried up to the commencement of the circular portion, and the whole of the flues are also lined with the same material. The floor of the engine house is of Carter's petrous tiles on concrete.

The internal surface of the walls to both the engine and boiler houses has a dado of Jennings' salt glazed bricks, the upper portion of the engine house walls being rendered with red Portland cement mortar. The engine and boiler foundations are of Portland cement concrete, and the boilers themselves are set on Poulton's patent blocks. A Kopple's stoke-hole truck is provided for conveying coal from the store to the boiler house, and all coal is passed over a weighing machine placed in the stoke-hole.

The workshop is provided with a lathe and forge, and the other plant and tools required for the execution of all ordinary repairs. The lathe will be driven by a small horizontal engine.

The superintendent's house contains a parlour, living room, kitchen and three bedrooms.

The waste water is conveyed by iron pipes to a water-tight covered cesspool, and a Moule's earth closet is provided in order to prevent contamination. The water will be raised from the well by two sets of three-throw pumps to the reservoir. The supply main is also the rising main, the water being delivered into it at the point where it passes under the workshop floor at the pumping station.

Each set of pumps is driven by a vertical inverted tandem compound surface condensing engine, having cylinders 8½ inches and 17 inches diameter, and 9-inch stroke, working at 150 revolutions per minute.

The two engines are exactly similar, and the respective parts are interchangeable. The barrels of the high-pressure cylinders are ¾ inch thick, and those of the low-pressure cylinders 1 inch thick; each cylinder, with the cylinder covers and valve-chest covers in position, being tested to 240 lbs. per square inch. The cylinders are lagged with polished teak secured by polished butt straps and screws. Brass indicator taps and sight feed lubricators are provided to each cylinder. The piston rods are of mild steel, 2¼ inches diameter. The crank shafts are of Siemens Martin mild steel, forged solid with the cranks and crank pins, and carry a fly-wheel 5 feet in diameter, weighing about 16 cwt. at one end, and a spur-wheel pinion for driving the pumps at the other end. The fly-wheels are provided with barring gear. The air pumps are of gun-metal, and are single-acting, 7½ inches diameter and 6-inch stroke.

The surface condensers have each 140 superficial feet of condensing surface, with tube plates of gun-metal 1⅛ inch thick. The tubes number 148 to each condenser, and are of solid drawn brass ¾ inch diameter, the inside surface being tinned.

Screwed brass ferrules are provided for making the joint between the tube and tube plates.

The engines are required to be able to run twelve hours without stoppage for lubrication, and means are provided for collecting all waste drip from every part of the machinery.

The boilers are fed by a direct-acting steam feed donkey-pump.

The pumps have working barrels of gun-metal ¾ inch thick and 8 inches diameter, with 18-inch stroke, and are suspended in the well, the end of suction pipe being at a depth of 157 feet from the surface.

The suction valves and pump-buckets are of gun-metal, of the Cornish double-beat type. The bucket rods are of 1½-inch diameter wrought iron, except the length which passes through the gland of the pump head, which is of phosphor bronze.

The separate lengths of pump rods are connected together by taper round socket and spigot joints, secured by gun-metal cotters. The rising main pipes are 8¾ inches internal diameter and ⅞ inch thickness of metal. All rising mains, stand and suction pipes have flanged joints, well bracketed between the bolt holes. Each joint has one flange with a recess turned in its face, and a spigot turned to the other flange to fit accurately into the recess.

An air vessel with automatic air charger, and a 3-inch diameter lever escape valve, are fitted to each rising main.

The pump crank shafts are steel forgings 7 inches diameter. Each shaft is driven by cast-iron gearing, the large wheel, 6 feet diameter and 6 inches wide, with 2½ inches pitch, bored to suit the pump crank shaft and keyed thereon.

Steam is supplied by two Cornish boilers, each 20 feet 6 inches long and 5 feet diameter, with internal flue 2 feet 9 inches diameter, having two cross tubes.

The boilers are interchangeable, so that either may be able to supply steam to either or both engines. The working steam pressure is 120 lbs. per square inch, and each boiler has been tested to a hydraulic pressure of 240 lbs. per square inch.

The steel used in the various parts of the boiler have been certified to have passed Lloyd's tests. Each boiler will be provided with one of Bayley's patent steam pressure recorders.

The whole of the machinery and the boilers have been supplied by Messrs. Easton, Anderson & Goolden, Limited, of Erith, Kent; the work, so far as can be at present ascertained, having been carried out in a most excellent manner. The total cost of the plant is 3200*l*.

The covered service reservoir is circular on plan, and is built entirely of concrete composed of 6 parts Moreton gravel to 1 part Portland cement. All cement used in the works is of the best quality, finely ground so as to pass through a sieve of 14,400 meshes per square inch without leaving more than 60 per cent. of its weight as residue, 80 per cent. of such residue to pass through a sieve of 5800 meshes per square inch, and the remainder through a sieve of 1600 meshes.

The specific gravity of the cement to be not less than 3·00, and briquettes of 1 square inch section to stand a tensile strain of 430 lbs. after one day in air and 20 days in water.

The reservoir is circular in plan and 90 feet internal diameter, the height from floor to top water level varying from 16 feet to 16 ft. 9 in. The external wall is 3 feet thick; the floor is laid to slope so as to drain towards the washout pipe, and is 1 foot thick. The concrete roof is also a foot thick, and is supported on eight cross walls 18 inches thick, and pierced with openings 10 feet by 8 feet.

The whole of the internal surfaces are rendered with two coats of Portland cement mortar, the first coat, $\frac{3}{4}$ inch thick, being composed of 1 part cement to 2 parts sand; and the second coat, $\frac{1}{2}$ inch thick, of 1 part cement to 1 part sand, and trowelled to a hard smooth surface.

The reservoir is ventilated by nine cast-iron ventilators of special pattern. The body of the ventilator extends through the earth covering from the concrete of roof. It is conical in form, 2 ft. 9 in. internal diameter at the base, and 12 inches at the top. The cast-iron cap is provided with vertical openings, a light iron tray being hung inside the ventilator to prevent any extraneous matter from entering the reservoir. The ventilators have been so designed principally to admit light to the reservoir when required for cleaning out, etc. When the caps are removed, sufficient daylight can be admitted to enable artificial light to be dispensed with.

A valve chamber is constructed outside the reservoir, and contains the valve on the rising and delivery main and on the wash-out pipe.

Water is admitted to and flows from the reservoir, by a floating arm. By this means the water is always drawn from about nine inches below the surface, so that no sediment or floating matter can find its way into the mains.

A Jennings' patent electrical mechanical indicator and recorder is fixed at the pumping station, and is electrically connected with the reservoir.

By means of this apparatus the level and quantity of the water in the reservoir is always known to the man in charge of the pumping station, and these particulars are also recorded on a diagram in a permanent form.

An endeavour is being made to come to an arrangement

with the National Telephone Company to connect the Author's office at Portland with the pumping station.

The water will be conveyed from the service reservoir at Upwey to Portland by 10-inch diameter cast-iron pipes. The line of pipes passes through the engine house, where it receives the water from the two sets of pumps, those pipes situated between the engine house and the reservoir acting both as a rising and a delivery main. The line between Upwey and Portland is practically straight, and is about 8½ miles in length, about 2½ miles passing through private property. The level of the lowest portion of the district to be supplied is 10·00 feet above Ordnance datum, and the level of the highest point requiring a supply, 490·00 feet above Ordnance datum. The main delivery pipe is therefore continued through Fortune's Well to the top of the hill, and the low-lying portions of the island are supplied by a system of low-pressure mains, the pressure being reduced by special valves inserted at the junction between the high-pressure and low-pressure mains.

The pressure-reducing valves have been manufactured by the Glenfield Iron Company, and are provided with weights for regulating the pressure so that it may be varied in case of fire, etc.

The pressure available throughout practically the whole of the island, with the exception of the Verne Citadel, is sufficient for fire-extinguishing purposes.

The cast-iron pipes are specified to be in accordance with the particulars mentioned in the table opposite.

All pipes above 5 inches diameter were cast vertically under a head of one foot of metal subsequently cut off.

The contractors were required to furnish a certificate from the manufacturers, certifying that the pipes had been properly tested to the pressure specified in the table. In addition it is the Author's practice to specify that the pipes are to be tested in sections after being laid in position and jointed. The results of the testing in connection with these works have demonstrated the importance of this provision, and the Author is of opinion that this system possesses many advantages over that often adopted of employing a professional pipe inspector to watch the casting and testing of the pipes at the manufacturer's works.

The testing of the first mile of main delivery pipe from the

TABLE No. 1.—THICKNESS, WEIGHT, ETC., OF CAST-IRON SOCKET PIPES.

	Internal Diameter.	Length of each Pipe, exclusive of Socket.	Thickness of Metal.	Weight (including socket). Per Pipe.			Weight (including socket). Per Yard.			To Carry Head in Vertical Feet.	To Carry Lbs. per Square Inch.	Working Head in Feet Vertical.	Depth of Socket.	Lead Joints. Thickness.	Lead Joints. Depth of Lead.
	inches.	feet.	inch.	cwt.	qrs.	lbs.	cwt.	qrs.	lbs.				inches.	inches.	inches.
A	10	9	·75	6	3	15	2	1	5	970	420	600	$4\frac{1}{2}$	$\frac{5}{16}$	$3\frac{1}{4}$
B	10	9	·67	6	0	6	2	0	2	930	400	500	$4\frac{1}{2}$	$\frac{5}{16}$	$3\frac{1}{4}$
C	10	9	·62	5	2	14	1	3	14	800	346	400	$4\frac{1}{2}$	$\frac{5}{16}$	$3\frac{1}{4}$
D	10	9	·57	5	0	22	1	2	26	600	260	300	$4\frac{1}{2}$	$\frac{5}{16}$	$3\frac{1}{4}$
A	9	9	·67	5	1	21	1	3	7	970	420	600	$4\frac{1}{2}$	$\frac{5}{16}$	$3\frac{1}{4}$
B	9	9	·63	5	0	14	1	2	24	930	400	500	$4\frac{1}{2}$	$\frac{5}{16}$	$3\frac{1}{4}$
C	9	9	·59	4	3	2	1	2	10	800	346	400	$4\frac{1}{2}$	$\frac{5}{16}$	$3\frac{1}{4}$
D	7	9	·50	3	1	2	1	0	10	600	260	300	$4\frac{1}{4}$	$\frac{5}{16}$	$3\frac{1}{8}$
A	6	9	·54	3	0	0	1	0	0	970	420	600	$4\frac{1}{4}$	$\frac{5}{16}$	$3\frac{1}{8}$
D	6	9	·44	2	1	27	0	3	9	600	260	300	$4\frac{1}{4}$	$\frac{5}{16}$	$3\frac{1}{8}$
D	5	9	·41	1	2	23	0	2	17	600	260	300	4	$\frac{5}{16}$	3
A	4	9	·45	1	2	21	0	2	7	970	420	600	4	$\frac{5}{16}$	3
B	4	9	·43	1	2	12	0	2	4	930	400	500	4	$\frac{5}{16}$	3
C	4	9	·41	1	2	3	0	2	1	800	346	400	4	$\frac{5}{16}$	3
D	4	9	·38	1	1	25	0	1	27	600	260	300	4	$\frac{5}{16}$	3
B, C, D	3	9	·38	1	0	8	0	1	12	930	400	500	$3\frac{1}{2}$	$\frac{1}{4}$	$2\frac{5}{8}$
	2	6	·34	0	1	25	0	0	18	930	450	500	2	$\frac{1}{4}$	$1\frac{1}{4}$

reservoir resulted in the discovery and removal of eighteen defective pipes. In many cases the pipes withstood the ordinary working pressure, but were subsequently found to contain cold shuts and other defects of a most serious nature. All pipes are coated internally and externally with Dr. Angus Smith's solution. The pipes are laid at the depths necessary to give a covering of 2 feet 9 inches of soil over the top. The whole of the special castings and fittings are tested to the same hydraulic pressure as the pipes to which they are connected or which are subjected to a corresponding working pressure. The fire hydrants are of the screw-down pattern with bayonet joints.

The sluice valves each have gun-metal screws and four gun-metal faces, and are fitted with the Glenfield Companies' patent stuffing box.

The air valves are of specially heavy construction, both the double and single valves being fitted with stop valves to enable the balls to be examined without shutting off the water in the main.

As far as practicable the service pipes to each house will be under the control of a stopcock provided by the council, and situated on the footpath outside the boundary of the premises supplied.

These stopcocks are of brass and are of the screw-down type, with loose valves for high pressure.

Two Deacon's meters, of 10-inch and 8-inch diameter respectively, have been provided, and the author anticipates that by these meters and the stopcocks it will be possible to effectually check waste.

The Author regrets that the works will be in an unfinished condition at the date fixed for the visit of the Association, but it may perhaps be of equal or even greater interest to some of the Members to see the works in course of construction than to inspect them when completed. They will at any rate have an opportunity to see in operation pumps which in the Author's opinion are the ideal pumps for well work.

The council, at the commencement of the contract, appointed Mr. C. Ballom as resident engineer on the works, and he has carried out his duties in a manner highly satisfactory to the Author. Mr. J. Peattie represented the contractors on the works, and has devoted practically the whole of his time to the management of these works.

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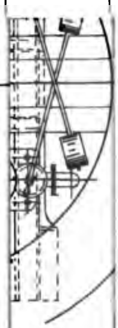

Ernest J. Elford.
Engineer.

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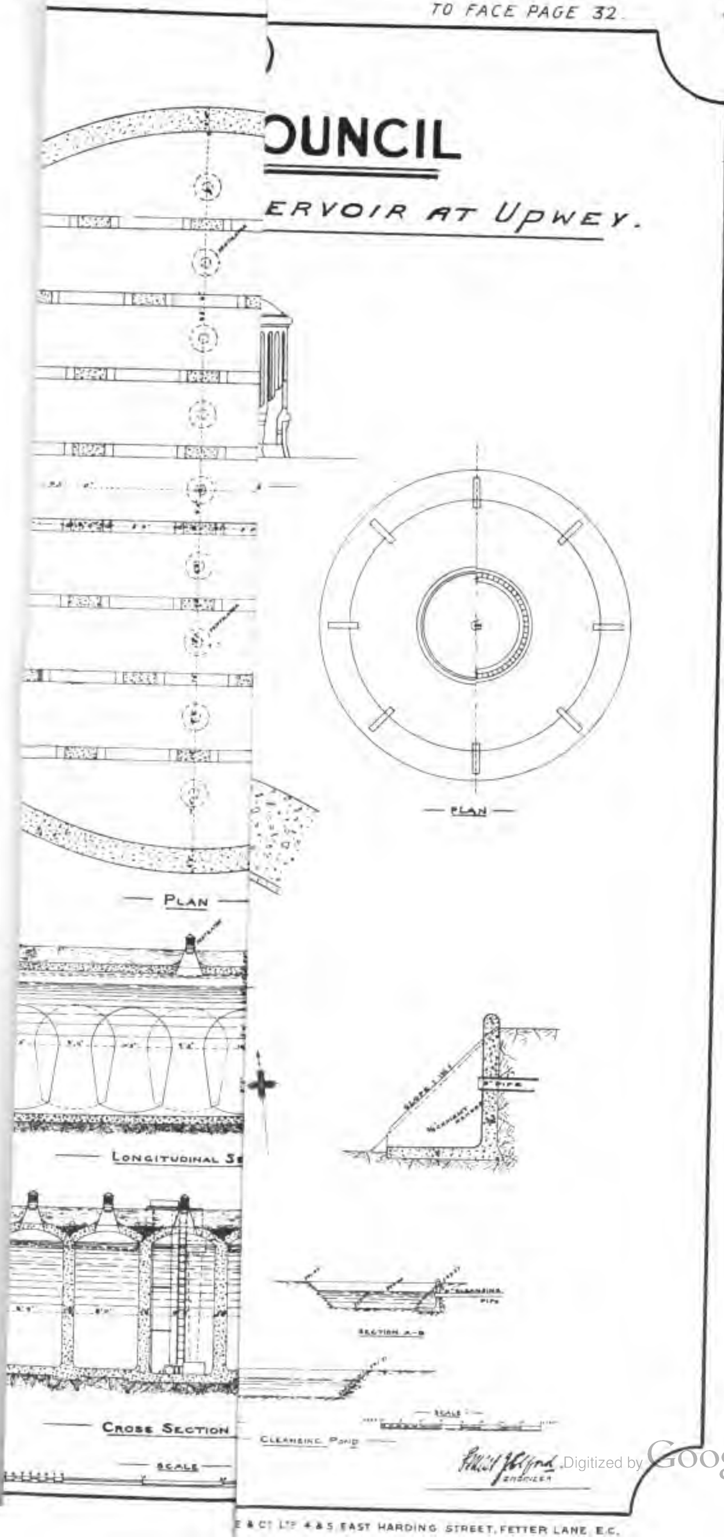
WELL

C° L^TD 4 & 5, EAST HARDING STREET, FETTER LANE, E.C.


OUNCIL
ERVOIR AT UPWEY.
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ENGINEER
E & Co Ltd 4 & 5 EAST HARDING STREET, FETTER LANE, E.C.

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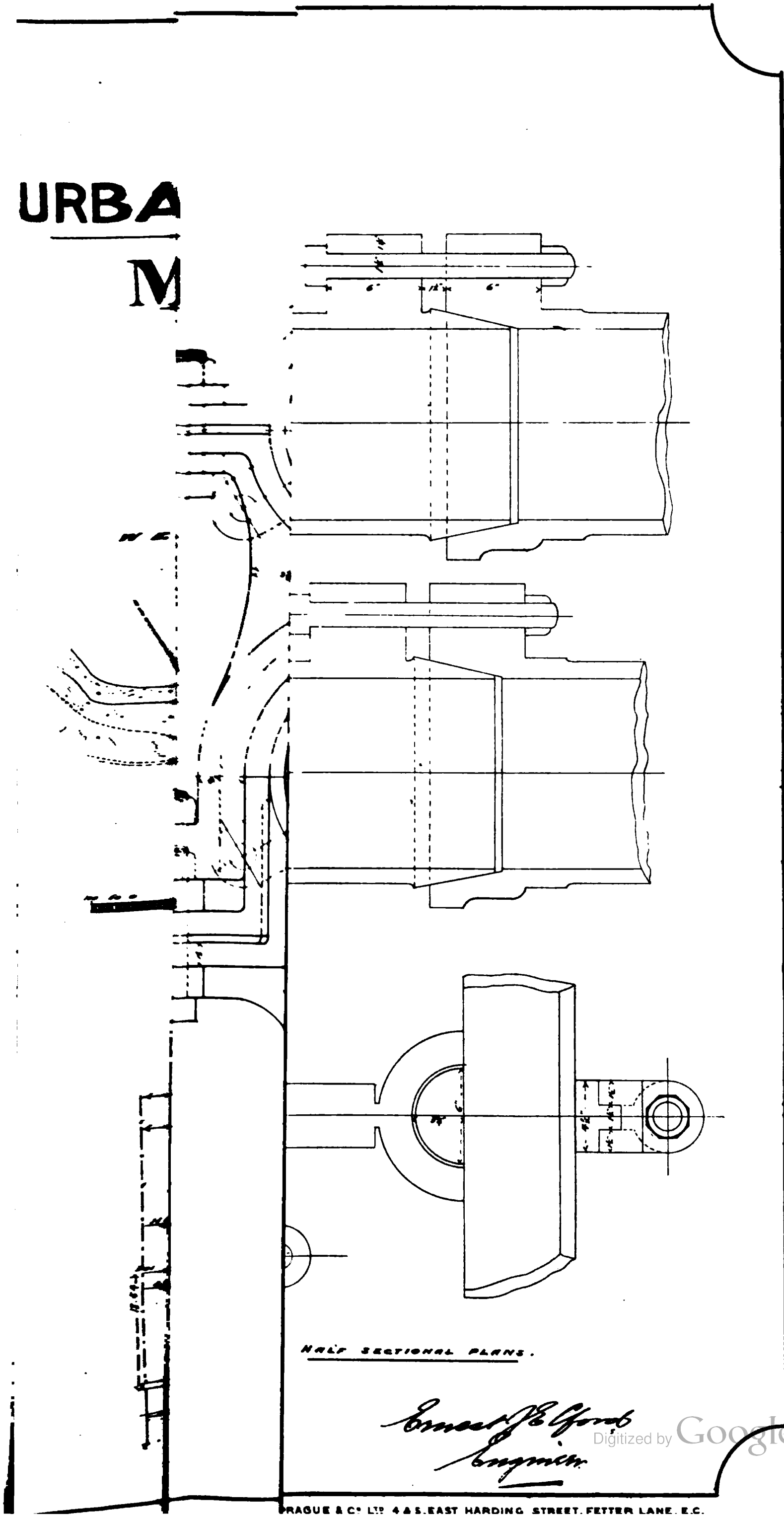
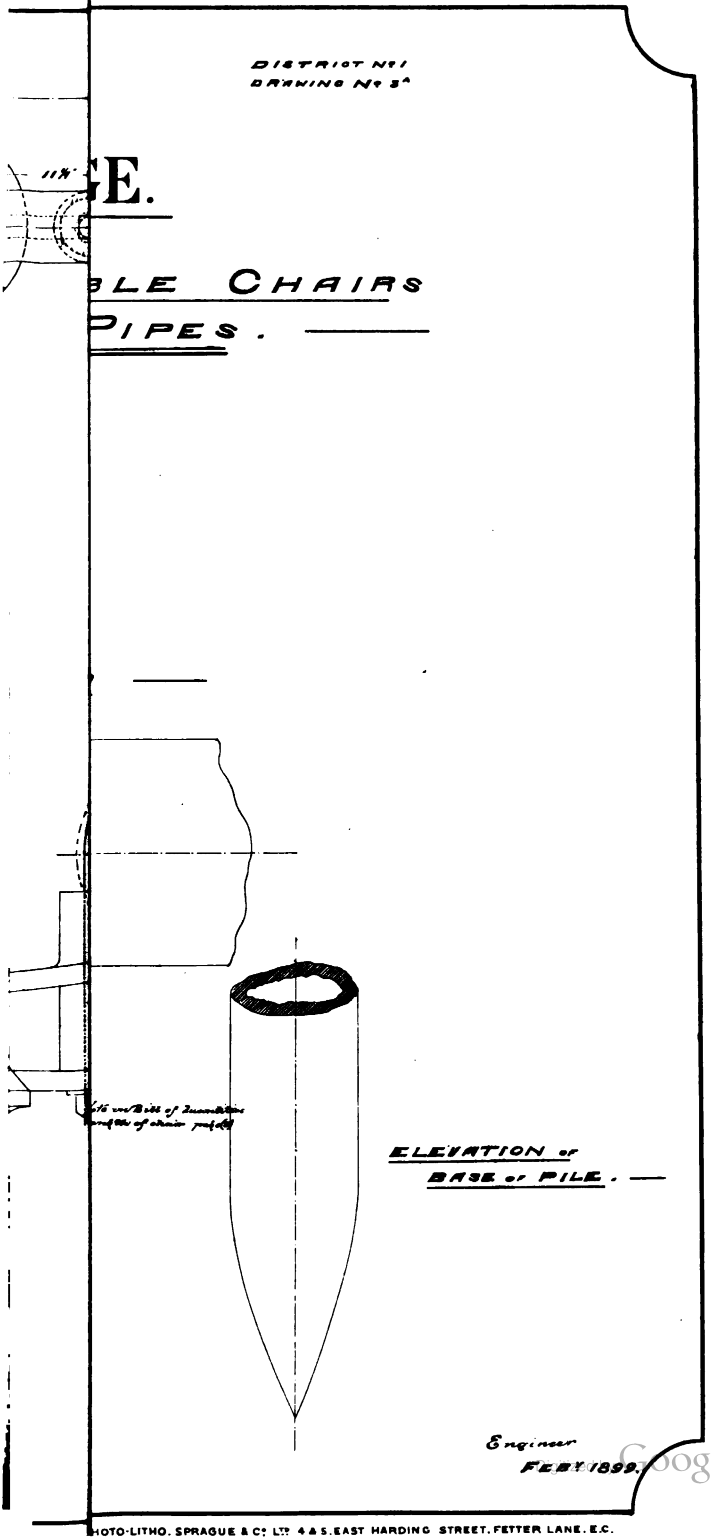


SPRAGUE & Co LTD 4 & 5. EAST HARDING STREET. FETTER LANE. E.C.



HOTO-LITHO. SPRAGUE & Co LTD 4 & 5. EAST HARDING STREET. FETTER LANE. E.C.

Having gone thus somewhat minutely into the question of the water supply, the Author will proceed to give some particulars, necessarily brief, of the

Drainage Works.

Until quite recently, the only means of draining the district was by the antiquated system of old stone drains, which, in the case of Portland, were originally open channels that had gradually been covered over. A considerable number of these old drains are still in use, and large areas of the district are still unprovided with any proper system of sewage disposal. The majority of the houses are provided with cesspools—mostly in a leaky and insanitary condition—for fæcal matter, and the slop and waste water is either thrown upon the gardens or into the surface gutters in front of the houses. When emptied, the contents of the cesspools are conveyed to disused quarries rented by the council, and the soil thus deposited is covered with house refuse.

One reason, and the most important one, why the question of drainage has been so long neglected by the local authority has been the impossibility of providing water for flushing purposes. The other reasons are similar to those generally advanced in opposition to drainage works, the principal one being unwillingness to incur the necessary expenditure.

The Local Government Board and Admiralty have, from time to time, brought pressure to bear upon the Local Board and subsequently the Urban District Council, impressing upon the local authority the absolute necessity of making a move towards providing a proper and efficient system of drainage; but the reply was always to the effect that it was impossible to drain without water. The force of this argument was fully realised by the Local Government Board and the Admiralty, who were compelled to wait until a satisfactory water scheme had been adopted before taking extreme measures. Happily it has not been found necessary to take these threatened "extreme measures," the Urban District Council—to their credit be it said—having fully realised their duty in the matter of the sewerage of their district, and are thereby protecting the pockets of the ratepayers, the consensus of opinion being that it is false economy to allow to exist in and around the homes of

a community conditions which must be a constant source of danger to the health and general well-being of the inhabitants. The action of the council is to be highly commended, seeing that they have, in the face of serious financial difficulties, resolved to do everything possible to fulfil the responsibilities which devolve upon them as the sanitary authority of the district.

In May last year, the Author received instructions to prepare a report on the drainage of the district, and estimates as to the probable cost of the necessary works. Accordingly he prepared a report, which was presented to the council in September last. After considerable discussion the scheme recommended by him was, with slight modifications, adopted by the council at a meeting held in October last, and the Author was requested to immediately prepare the scheme in detail for submission to the Local Government Board. This was done, and the whole of the drawings, estimates, etc., were sent to the Board within four months of the final adoption of the scheme.

On May 26 last, Mr. H. P. Boulnois, M. Inst. C.E., Local Government Board Inspector, held a local inquiry, and expressed satisfaction with the scheme; but up to the time of writing no communication has been received from the Board. There can be no doubt as to what the decision of the Local Government Board will be after the expression of opinion from their inspector; and when the district is properly drained, there is no reason why the Isle of Portland should not gain as high a reputation as a health resort as it has in the naval world by means of its breakwater, especially as, under the unfavourable conditions at present existing, the average death rate is only about 12 per thousand.

For the purposes of drainage the island has been divided into four districts having three separate outfalls. No. 1 district includes the whole of the northern slope of the island, containing a population estimated at about 4000. This district is at present drained principally by old and more or less defective sewers into the Portland roadstead. Some twenty-five years ago, however, the Local Board of Portland entered into an agreement with the Admiralty, by which the local authority obtained powers to construct an outfall for surface water into the roadstead, on the condition that no fæcal matter should be permitted to enter the

drains. Since that time it has been found practically impossible to comply with this condition, and consequently the Admiralty served notice on the authorities to discontinue the use of the outfall referred to, and requested them to provide this portion of their district with a complete sewerage system. The Admiralty suggested that the sewage should be discharged into the West Bay, and offered to make a contribution towards the cost of the scheme should their suggestion be satisfactorily carried out. The present scheme provides for the construction of an outfall in the West Bay. This will render it necessary to raise the sewage of two small areas, viz. Chiseltown and Castletown, and to accomplish this it is proposed to adopt the Adams' patent sewage lift. The air for working the Chiseltown lift will be compressed by the action of the high-level sewage, the compressing cylinder being situated at a distance of 230 yards from the lift. The compressed air will be conveyed to the latter by a 2-inch air main. The working expenses of this lift will therefore be practically nil. The maximum quantity of sewage from the Chiseltown lift area is estimated at 1000 gallons per hour, and will require to be lifted to a total height of 10 feet.

At Castletown no high-level sewage will be available, and the power required for air-compressing will therefore have to be supplied by water from the Council's mains.

The total maximum quantity of sewage from the Castletown lift area is estimated at 500 gallons per hour. This will have to be lifted to a total height, including friction, of 48 feet through a 4-inch cast-iron rising main, 280 feet in length.

With the two exceptions last referred to, the whole of the drainage from No. 1 district will gravitate to the outfall. In this district the sewers will be required to take both surface and storm water, except from the lift areas.

The outfall will consist of 12-inch diameter cast-iron pipes, having turned and bored joints, each joint being bolted together by three bolts passing through lugs cast on the pipes. The pipes will be carried on cast-iron screw piles, to which they will be secured by special cast-iron chairs. The piles will be screwed to a depth of about 6 feet into the Kimmeridge clay. The 12-inch outfall pipe will, at the gradient provided, be of sufficient capacity to take the maximum flow of sewage, and also the rainfall to the extent of ·57 inch per hour. A

12-inch overflow pipe will be provided to take the flow of rainfall in excess of the above. The outfall pipe will be carried out to a distance of 100 yards from low-water mark spring tides, and will be in a depth of water at the discharge end of 17 feet below low-water level. The overflow pipe will be carried to below low-water mark spring tides.

The whole of the ironwork will be strongly constructed to resist the heavy seas which are of frequent occurrence on this coast. The chairs have been designed with a view to enabling them and the piles to be easily fixed, and in order that the overflow pipe may, with little difficulty, be subsequently lengthened if found necessary.

Tidal observations, extending over about a month, were taken in the neighbourhood of the outfall, the result of these observations being most satisfactory.

District No. 2 includes the Grove and Easton. The population to be provided for in this district is about 4250. The separate system will be adopted as far as practicable, the rainfall being dealt with by the surface water drains at present existing. No attempt has yet been made to sewer any portion of this district, the whole of the houses being provided with cesspools or earth closets. The principal difficulty met with in devising a sewerage system for this district is the rock which forms the substrata. This difficulty has, however, been avoided to a great extent by making provision for the sewers, in two important instances, to be carried through private property where a considerable depth of rubble exists, thus enabling the sewers to be constructed at a sufficient depth to obtain good gradients without entering the rock.

The natural drainage course for this district lies along the valley, which runs through the grounds of Pennsylvania Castle and terminates in Church Hope Cove. It is, in fact, along this course that the surface drainage at the present time finds its way, discharging ultimately into the cove.

The construction of a sewer, however, through the castle grounds, and of an outfall in Church Hope Cove, would, no doubt, have been strenuously opposed, both by the owner of the castle and the general public who use the cove as a pleasure resort; and another drawback would have been the heavy claims for compensation which the council would no doubt have had to meet.

The Author's scheme therefore provides for the construction of an outfall at a point about a quarter of a mile south of the cove, where there is a practically vertical drop of about 50 feet down the face of the cliff into the sea. The tidal observations at this point also gave very satisfactory results.

No. 3 district includes the village of Weston, where there is a population of about 500 to deal with. The sewage from this district will be discharged by the same outfall as provided for No. 2 district.

The remaining district includes the village of Southwell, the population of which is estimated at 250. The sewers in this district are designed to take both the sewage and rain water, which will be discharged into the sea by a 9-inch cast-iron outfall pipe attached to the face of the cliff at a point situated about a ½ mile from the village.

The gradients throughout the island are exceptionally good, and it is not proposed therefore to introduce any special flushing apparatus. The ventilation of the sewers will be principally by ordinary manholes and lampholes, and these, where the gradients are very heavy, will be constructed with tumbling bays and copper air flaps. A few tall ventilating shafts will be erected at points where the streets are very narrow.

The total cost of the scheme, including the renewal of all old sewers, is estimated at 24,000*l.* The Author has received instructions to advertise for tenders immediately the sanction of the Local Government Board comes to hand.

In conclusion, the Author would like to take this opportunity to express his appreciation of the kindness and consideration he has experienced at the hands of the members of the council and to thank them for the confidence they have manifested in him, especially in connection with the above works.

NOTES ON PORTLAND STONE.

By ERNEST J. ELFORD, Surveyor to the Urban District Council, Portland.

In the following brief notes the Author proposes to describe shortly the various beds found upon the Island of Portland, commencing at the surface. The beds of marketable stone will be described more fully than those which, although of interest geologically, are of little, if any, commercial value.

The surface of the island consists of a thin layer of soil varying generally from 6 inches to 1 foot in thickness, but in a few instances reaching a thickness of 3 to 4 feet.

The beds immediately below the surface are the fresh-water deposits of the Purbeckian series. The latest of these beds consist of Purbeck clay and shingle, which is followed by thin beds of slaty stone.

The best quality stone from the latter beds is used for the foundations of roads and for macadam where the traffic is light. It is also used largely for dry walling; most of the boundaries to land being of this material. That known locally as "hard blue slate" is very hard and crystalline in character.

The Author has broken large quantities of this stone for tar paving with very satisfactory results; one of the principal advantages resulting from its use in this capacity being that it does not wear slippery.

Bacon Tier and Aish.

The bacon tier and aish are situated next below the above beds. They are of no commercial value.

Soft Burr.

The aish is followed by a bed about 18 inches in thickness known as "soft burr." This is a soft stone, easily worked, but

of very inferior quality; it is used for small buildings, but as it is of a very porous nature the external walls of such buildings require to be rendered with cement to prevent the ingress of damp.

It is never exported for building purposes, but is frequently used locally for chimney work as it possesses fire-resisting qualities. This stone is not worked by the quarry merchants, it is looked upon as a perquisite of the quarry men, who work it into ashlars in their spare time.

Dirt Bed.

Next in order we find the Great Dirt Bed—a bed of black soil about 1 foot thick.

Lying in this bed are the fossil remains of trees. In many cases the roots of trees are found with the trunk standing erect to a height of nearly 3 feet. This bed is evidently the remains of an ancient forest, the trees of which grew thickly together.

Cap.

Following the Great Dirt Bed is the "Cap," a bed of stone from 6 to 8 feet in thickness.

This stone is of a hard, close and flinty texture, and is for this reason very difficult to work. It is treated by the quarry merchants as a waste product, and thousands of tons may be seen throughout the island stacked in the rubble beaches. In clearing the quarry this stone is blasted, the smaller pieces being used to some extent for road-making and other similar purposes. When broken to about 2½ inches it forms a very good material for roads with light traffic.

The Author uses a small proportion with granite and other hard stone, and finds that the Cap forms an excellent binding material, and that the combination wears well, even under the exceptionally heavy traffic of the district.

This stone is also used for tar paving, with similar results to those obtained from the use of the slate stone described above. Recently setts have been made from Cap, and have been used for crossings, etc. They are clean and non-slippery, and appear to wear well.

Lower Dirt Bed.

The Lower Dirt Bed is next below the Cap. It is of a clayey character, contains no trees and but few fossils, and is from 3 to 4 inches thick.

Skull Cap.

The Skull Cap underlying the Lower Dirt Bed is the lowest bed of the Purbeck series. It varies from 1 to 3 feet in thickness, is somewhat similar in character to the Top Cap, but is entirely a waste product.

Roach.

The top bed of the Portland series is the Roach. This stone is very hard and tough, and somewhat silicious. It is composed principally of fossils united by a cement of carbonate of lime. It is so crowded with casts of shells as to be unfit for architectural or other fine work; but from its great strength and durability, and its excellent weathering qualities, it is admirably adapted for engineering works. Large quantities are used for fortifications, sea walls, engine-beds and other work where weight and strength are required, and where a smooth fine surface is unnecessary. A fine example of Roach work is the St. George's Church, Portland, built in 1764 entirely of this kind of stone, upon which the tool marks can still be plainly seen.

Whit Bed.

Underneath and joined to the Roach is the Whit Bed. It is from this tier that the best English stone for external work is obtained. The exact line at which the Roach ends and the Whit Bed begins is undefinable, and the relative thicknesses of the two beds vary considerably in different quarries. In one case, coming under the Author's notice, the whole tier was composed of Roach. When first raised the stone is of a brownish tint, but subsequently changes to white as the quarry water is evaporated from it.

Few shells are, as a rule, present in this stone, which varies in texture from a fine close grain to a coarse oolitic structure. This stone is never blasted; it is split by wedges and removed

by hand cranes, blocks of from half a ton to upwards of twelve tons being obtained.

The quarries are open cut, the whole of the work, including the squaring of the blocks, being accomplished by hand labour. The best selling stone, styled by the trade "Bird's-eye Portland," and consequently that considered by quarry merchants to be of the best quality, is that from the northern part of the island, which is now nearly worked out.

The stone which remains is harder and more difficult to work than that just referred to, and in consequence is not so highly favoured by masons, builders and contractors. This harder quality stone, especially that from the east of the island, is the more durable, and the engineer and architect will find that, from their point of view, it is much to be preferred.

Base Bed.

The stone from this bed is often termed "Best Bed" or "White Portland." These expressions are both incorrect and misleading, and it has frequently happened that Base Bed stone has been supplied for work for which it is quite unsuited. This stone is whiter in colour, finer in grain, more absorbent and softer, and more easily worked, and has fewer shells than Whit Bed. It is therefore unfit for exterior work, but is admirable for statuary and interiors. Unfortunately for the reputation of Portland stone, large quantities are used for exterior work.

It is in great demand by builders and contractors for practically every kind of work, as although it is higher in price the expenditure for labour in working is so much less than for Whit Bed, that a much higher rate of profit can be secured.

Speaking generally, large stones are the hardest and best, as it is impossible to "make" large stones in a quarry where the beds are unsound and full of vents. It frequently occurs, however, that the Whit Bed and Base Bed vary very much in quality in the same quarry. One bed may be unfit for the market, while the other is of excellent quality. A stone that rings well on being sharply struck with the tool is generally sound, but this is not invariably the case, as if a vent is confined entirely within the stone—in other words, if the vent does not extend to the outside of the stone at any point—it is probable that the latter will ring well.

It is the invariable rule for architects and engineers to specify that Portland stone—and in fact, practically all other stone—must be laid on its natural bed. In the Author's mind however, there is a doubt as to whether it is wise to do this in the case of Portland stone. Throughout the island, both the Base Bed and the Whit Bed are split up by vertical fissures, and the small fissures or vents within the stone itself also follow a vertical direction. These latter are often undiscernible, but are invariably a source of weakness, especially in the case of long door and window-heads, sills, etc. The natural bed of Portland stone is undefined, and even men of great experience often find it difficult to say which is the natural bed of a particular stone; practically, the only guide being the position of the shells.

The Author's practice is to specify that the stone shall, as far as practicable, be laid with its natural bed at right angles to the face of the work, as the weathering qualities of the stone would probably be impaired if it were laid with its bed parallel to the face of the work. In conclusion, he would suggest that the following description of the respective kinds of stone should be used when specifying, viz.: Best hard Portland Whit Bed; Best Portland Whit Bed Roach; or Best Portland Base Bed. If this course is adopted, considerable confusion will be avoided, and less difficulty experienced in obtaining stone of the required kind and quality.

DISCUSSION.

The PRESIDENT: I have much pleasure in proposing a very hearty vote of thanks to Mr. Elford for the two valuable papers he has submitted to the meeting. Our visit to the Waterworks this morning was a most interesting and instructive one. In the paper before us we have a history of the troubles and difficulties which the Portland District Council have met with in procuring a supply of pure water. After what we saw at the works this morning we may say those difficulties have been mastered. You have now obtained a plentiful supply of good water. The paper on Portland Stone is one I am particularly interested in at the present time. Cardiff is about to build a new Town Hall on which we propose to spend 250,000*l.*,

and we decided to have Portland stone for our building. Now our troubles have commenced, because our architect tells us there is so much demand for Portland stone that we shall not get our building erected in a reasonable time. If we are to have it erected in a reasonable time he says we must use some other material. Whether the assertion is true or not, I hope the Portland people will find us a way out of our difficulties, and give us a guarantee to supply us with stone of proper quality and in sufficient quantity to keep our building going without delay. The particulars which Mr. Elford has given us as to the kinds and beds of stone are extremely valuable. It is information which no Member of the Association will forget, and when we have to specify for Portland stone the paper will be looked upon as a text book for the specification. The value of information of this sort to us is incalculable, and it is of equal value to the Councils we represent.

Mr. J. PATON: I have very great pleasure in seconding the vote of thanks to Mr. Elford for his very valuable papers. I am sure Mr. Elford, in the work he has done, has served his authority admirably.

The vote of thanks was accorded with acclamation.

Mr. ELFORD, in reply, said: It is with very great pleasure that I have this opportunity of acknowledging the very kind vote of thanks you have passed to me. I am glad you have found something in your visit here that has been of interest, and I hope the remainder of the day's proceedings will be of equal interest. The work we have had before us, the difficulties we have had to meet, one after another, during the last four or five years have at times almost taken the heart out of us, but I am very glad to say at the present time we appear to be getting over the worst of them, and I hope and believe there is a more hopeful future before us than there appeared to be a few years ago.

Immediately following the reading of the papers, the Members paid a visit of inspection to the Waterworks, returning thence to the Royal Hotel for luncheon. The afternoon was devoted to visits to the Weymouth Torpedo Works, where all the workshops were opened for inspection, and to the workshops at Portland Convict Prison.

DISTRICT MEETING AT MERTHYR TYDFIL.

September 23, 1899.

Held in the Town Hall, Merthyr.

C. H. Lowe, M. Inst. C.E., President, *in the chair.*

The High Constable (Mr. Owen, J.P.) and the Members of the District Council received the Members and welcomed them to Merthyr.

He said the Council and the ratepayers of Methyr Tydfil were very pleased to receive a visit of the Members of the Association of Municipal and County Engineers, and on their behalf he offered a hearty welcome to the town. He hoped at the close of the day's proceedings the Members would be able to say they had seen something worthy of their visit.

The President, in acknowledgment, thanked Mr. Owen for the cordial welcome extended to the Association. He was reminded of the fact that at Merthyr he received his training as a Municipal Engineer.

Mr. W. E. C. Thomas (Neath), Honorary District Secretary, read the minutes of the last District Meeting, which were confirmed.

Mr. Thomas was then unanimously re-elected Hon. Secretary for the South Wales District.

The following paper was then read.

THE MERTHYR WATERWORKS.

BY T. F. HARVEY, ENGINEER AND SURVEYOR TO THE URBAN DISTRICT COUNCIL.

THE area of the Merthyr Tydvil Urban District Council comprises the entire parish of Merthyr Tydvil, which is situated in the northern part of the County of Glamorgan and contains an area of 17,759 acres with a population of over 72,000. The key map shows the centres of population within the district and the reservoirs and lines of main for the supply of water. The town of Merthyr lies at the north of the parish and adjoins that of Dowlais, the two places containing five-sevenths of the population of the whole parish. Merthyr owes its importance to its being on the northern outcrop of the South Wales coal basin, and its modern history to the gradual development of the mineral wealth of the district. The extensive iron and steel works and collieries adjacent to Merthyr of Dowlais and of Cyfarthfa—which are still among the giant concerns of the country—were in existence a century ago, although at that time the output of iron and coal was small. It was not until the practical genius of our countrymen had begun to plant down the iron road that these ironworks became so famous and the means of bringing together so large a population, which has increased as shown by the following census returns:—

Year 1831	22,083	Year 1871	51,891
„ 1841	34,978	„ 1881	48,857
„ 1851	46,389	„ 1891	58,500
„ 1861	49,810	„ 1898	71,903*

In 1852 a private company obtained an Act of Parliament to provide a water supply for Merthyr, but the works were not carried out, and the people had to wait a few more years before the boon of a constant water supply was provided.

* Estimated at end of year.

Pentwyn Reservoir.

In 1858, the Local Board of Health obtained their first Water Act authorising them to impound the waters of the river Taff Fechan (which takes its rise on the southern slope of the Breconshire Beacons) for the supply of their district, according to the plans of the late eminent engineer Mr. Thos. Hawksley, who carried out the whole of the works, the capital expended amounting to 82,000*l.*; and from this time the district has had an abundant supply of the purest of water, except in seasons of long drought.

The impounding reservoir of this scheme drains an area of 4500 acres, chiefly mountain pasture on the Old Red Sandstone; and a further 500 acres on the south-east side of the reservoir is intercepted by a branch of the 14-inch main; the distance from the embankment of the reservoir to the northern edge of the watershed on the summit of the Brecon Beacons being 5·3 miles.

The embankment, which is an earthen one, crosses the valley at a narrow neck, and its height is 34 feet above the river bed, and 1084 feet Ordnance datum. The site was, no doubt, selected on account of its cheapness; and, although the embankment is only a shallow one, the top water area is 96 acres, and the capacity 346 million gallons. Unfortunately, the carboniferous limestone overlies the Old Red Sandstone where the embankment was made, with the result that a serious leakage through the fissures of the limestone rock has always existed, and has caused much expense and anxiety to the authority, which leakage, however, is measured over the gauge below the dam as compensation water to the riparian owners.

It is very seldom that a finer site for an impounding reservoir is seen than this, and it is unfortunate for the rate-payers that its natural advantages should have been only so partially utilised; for if the embankment had been made 500 yards further north, the foundation would have been on the Old Red Sandstone; and if its height had been doubled the reservoir would have had a top water area of 190 acres, and a capacity of at least 1500 million gallons; and moreover, the cost of such an embankment would have been absurdly small for the volume of water which would have been impounded. Such a reservoir would have done away with the necessity of

the additional storage now being provided, and of the works to be described further on.

The Compensation Clauses in the Act are very favourable to the riparian owners, inasmuch as the actual working of the clauses has resulted generally in the discharging of 11½ million gallons *per diem* when the reservoir contains more than about one-third of its full capacity, as it does for a considerable part of the year. When, however, the quantity of water stored in the reservoir falls to one-third of its full capacity, the compensation water discharged is reduced to less than one million gallons per day.

A 14-inch main, 6⅓ miles in length, conveys the water from the reservoir to the filtering and pumping station, where (until a second storage reservoir was constructed in the upper part of the watershed) a pair of vertical engines of the condensing type pumped water to a covered service reservoir of 343,000 gallons capacity in the upper part of the district at an altitude of 1205 feet Ordnance datum.

This filtering station comprises two open depositing tanks 153 by 66 by 7 feet, four filter beds 100 by 50 feet each, and a covered service tank 99 by 65 by 15 feet. The 14-inch main is continued from the filter beds to Merthyr a further distance of 1⅓ miles, and from thence a smaller main supplies the outlying places six miles down the valley.

Lower Neuadd Reservoir.

In consequence of the expansion of the district, and especially the deep sinkings to the steam coal in the southern portion of the district, it was deemed advisable to construct an additional storage reservoir, and in 1876 a provisional order was obtained and the Lower Neuadd Reservoir afterwards constructed. This reservoir obviates the necessity of pumping, the top water level being 1412 feet Ordnance datum. The capacity when full is about 75 million gallons, and an independent line of 12-inch main takes the water to separate filter beds at such a height as to flow therefrom by gravitation to the old service reservoir at the end of the pumping main, near the highest part of Dowlais, for the supply of Dowlais and other high parts of the district, and thence by a smaller main to the southern part of the district (Treharris and Quaker's Yard) a further distance of 8½ miles

for the supply of about 8000 persons within the district, and 3000 outside the Council's area. At Treharris the Author is now constructing for the Council an open service reservoir of lime concrete, to contain 350,000 gallons.

Upper Neuadd Reservoir.

In 1886 the Author marked out a site about half a mile north of the Lower Neuadd Reservoir which he considered a suitable one for an embankment should further storage capacity become necessary, but it was not until towards the close of protracted litigation with respect to the rights of the riparian owners to compensation water from the Lower Neuadd Reservoir that steps were taken to obtain further Parliamentary powers, and to engage Mr. G. F. Deacon, M. Inst. C.E., of Westminister, to advise the local authority as their engineer. In 1895 the Act was obtained under which the Upper Neuadd Reservoir is now in course of construction for the Merthyr Urban District Council by the engineer for the works, Mr. G. F. Deacon, and under the charge of the Author who is the resident engineer, the site of the dam being virtually that selected by him in 1886.

Owing to the conformation of the valley above the Lower Neuadd Reservoir no site exists for a short embankment to impound any large quantity of water, and therefore the masonry dam in course of construction is of considerable length; but although the site is a costly one for a low embankment, it is favourable to the construction of a comparatively large reservoir; and having in view the prospective demand for water to districts outside the limits of the Merthyr area, the local authority were justified, in the Author's opinion, in deciding to construct a reservoir which would not only meet their own requirements but would yield a large surplus of water to meet demands from outside sources, and produce revenue to aid in the repayment of the capital borrowed under the Act, and especially so because the initial cost for a small reservoir would be so much greater per unit of capacity than for a large one.

The rainfall on the catchment area is high. It has been registered at the Pentwyn and Lower Neuadd Reservoirs since 1887. In 1894 several additional rain gauges were established in the upper portion of the gathering ground with the object of obtaining a more correct average. The difference in the

depth of rain at the various gauges within the upper portion of the catchment area has been found to be very great, and is shown by the following tables giving the yearly totals:—

RAINFALL IN INCHES (1888 TO 1894).

Height above Sea Level, in feet.	—	1888.	1889.	1890.	1891.	1892.	1893.	1894.
1120	Pentwyn Reservoir	61·90	44·06	52·34	75·56	45·96	54·98	72·24
1462	Neuadd „	63·13	50·58	56·15	76·47	45·13	57·36	74·63

RAINFALL IN INCHES (1895 TO 1898).

Height above Sea Level, in feet.	—	1895.	1896.	1897.	1898.
1120	Pentwyn Reservoir (east side)	60·89	55·05	75·87	60·89
1462	Lower Neuadd Reservoir „	60·03	56·98	73·78	68·62
1487	„ „ „	70·15	65·07	88·10	79·18
1993	West side of River Taff Fechan ..	69·03	64·49	83·87	79·70
1515	Near river, north end of Upper Neuadd Reservoir	74·26	70·58	90·10	82·95
2017	West side of river	74·68	70·05	89·27	77·62
1723	Near river	79·63	73·34	97·15	87·36
1843	East of river	52·96	48·65	57·90	53·81
1997	„	54·22	49·29	61·04	55·31
2099	Near river, at the foot of the "Beacons"	83·65	74·52	101·54	91·31

Before the works were commenced, and in order to save time, the Council laid down a temporary railway two miles in length to connect the site with the Brecon and Merthyr Railway, at Torpantau, and erected several huts for the accommodation of the workmen, which have since been supplemented by additional ones, as well as by the erection of a mission room (used also as a schoolroom), and other temporary erections. A 9-inch outfall sewer drains most of the huts to a point below the Lower Neuadd Reservoir where a small pair of sewage tanks was constructed.

Description of Works.—The Merthyr Council, by the advice of their engineer, advertised in October 1895 for tenders for excavating and embanking earth and rock, providing and delivering materials for masonry and concrete and for othe

works, and accepted the tender of Messrs. Holme and King, of Liverpool and London, whose tender, however, was not the lowest. "The contract does not include the actual manipulation of the building materials upon the surface of the concrete of masonry to be used in the formation of the permanent dam, or upon the surface of the rock forming the foundation of such dam."

The work is, therefore, partly done by the contractors and partly by the Council; the part done by the contractors includes the supply and delivery of all materials, the excavation and timbering of trenches, all works of a temporary nature, and all machinery, locomotives, gauntries and apparatus, while the work of the Council's workmen consists of the actual building of the permanent dam whether in concrete or masonry. None of the contractors' men are engaged upon the dam itself. The principle involved in this dual execution of the works is that of endeavouring to leave no loop-hole for defective building of the dam.

The reservoir will contain about 350 million gallons, the surface area at top water level being 59 acres and drainage area 2018 acres. The height from the bed of the river at the vertical face of the dam to top water level is 67 feet 3 inches, the level of overflow being 1506·5 feet Ordnance datum. The total length of the dam is 1622 feet, of which 1390 feet will be visible above ground. The dam crosses the valley nearly east and west, the formation being Old Red Sandstone. The bed rock appears in the river bed near the site, and hence, although the length of the dam is considerable, the depth of foundation for the heavy overflow portion of the dam in the middle is not great, and the site, therefore, is not unfavourable for a comparatively large reservoir.

The river was diverted, until the permanent tunnel, which is 10 feet in diameter, was built, through a timber trough 200 feet long, made of 4-inch timber, grooved and tongued with hoop-iron, and having a bell-mouth inlet end 40 feet wide, the sectional area of the trough being 15 feet by 3 feet 6 inches, laid to an inclination of 1 in 50 in the direct line of the stream over the foundation of the dam which was brought up to within 2½ feet of the bottom of the trough, and left until the tunnel was ready to receive the flow of the river.

The height of the dam from the foundation to the footwalk

is 84 feet 6 inches. The cross sections are of three different classes. The central or overflow portion, 89 feet wide, is so designed that the weight of the structure alone, whether the reservoir be full or empty, keeps the centre of resistance well within the middle third of the base. This portion is curved in plan, not for additional strength, but rather to direct the main overflow towards the centre line. Immediately east and west of the two towers flanking the overflow the cross section is also such that without extraneous aid the centre of pressure always lies within the middle third of the base. Still further east and west, where a large portion of the dam is below ground, the excavated material is embanked against the concrete and masonry, and a portion of the supporting pressure due to the earthwork is credited to the dam, so that the base is narrower, though the dam is really stronger than it would be if standing alone and designed with a full gravity section.

The face of the dam is built to a straight line in plan except the overflow portion in the middle part of the dam, which is curved convexly towards the reservoir to a radius of 310 feet. The overflow portion between the pilasters or ribbons is 89 feet in length, which near the top is divided into six bays of 12 feet each, in which will be fitted greenheart stop planks to a depth below overflow level of 4 feet. On the east side of the overflow, a tower will be carried up to a height of about 55 feet, which will contain the tank for flushing the intake and strainer, and the lower part of which will serve as the valve chamber. The west side will be finished by a turret, and a planked foot bridge will be constructed over the overflow.

Whatever the height of water in the reservoir, the water for the main (which will be 16 inches diameter) will be drawn from near the surface, and will be strained through frames of copper wire gauze, without reducing the reservoir head upon the pipes to that of the outlet level. In the face of the masonry below the tower, for nearly the whole depth of the dam, is a vertical chase or groove 4 feet deep and 5 feet wide, the water within which will stand at substantially the same height as the water in the reservoir, but will be separated therefrom by a vertical partition containing light flap valves at different levels. The whole of these valves will, at all times, hang in the closed position, except the one immediately beneath the water level for the time being. This particular valve will be held open

by a float until a change of the surface level (by lowering or raising the float) causes it to allow the valve last open to close, and to open another. At the bottom of this groove (which, as it will contain only surface water, will be called the surface water chamber) there is constructed an outlet chamber communicating directly with the draw-off pipes and valves. One vertical face of this outlet chamber will be provided with grooves into which will slide the screening frames, separating the outlet chamber from the surface water chamber. Each strainer frame may be drawn to the surface for repairs, while a second strainer remains in position to do the work, and the strainers may at any moment be cleansed while in position by reversing the flow through them. This will be effected by causing the water from a large tank in the tower to discharge suddenly into the outlet chamber, thus raising the hydrostatic pressure in this chamber much beyond that in the surface water chamber. The general principle, but modified in form, is the same as that employed by Mr. Deacon at Lake Vyrnwy, where the cylindrical strainers, after being raised above the water, are perfectly cleansed by a reverse current from a series of pipes caused to revolve automatically, turbine-like, within them. At Upper Neuadd, cleansing will be performed more simply, without lifting the strainers.

The foundation on both sides of the middle part of the dam is taken down through the drift, and through a considerable depth of marl and loose rock to sound rock, or near the end of the trenches to hard marl. The marl and rock alternate in the strata, and the beds of rock run out in an irregular fashion, the marl, however, being a good water-tight foundation. On the west side a dislocation or minor fault occurred in the strata, and the fissure passing diagonally across the trench was cleared out to a depth of 14 feet to a rock bottom and filled with cement concrete. The quantity of water met with in sinking the trenches was not at any time very great—which in this formation is as might be expected. Along the face of the foundation, and within a foot or so of the face of the work, a narrow trench was cut into the rock, so that the deepest part of the trench is towards the water face. A 9-inch stoneware drain was laid to a suitable inclination either on the rock bottom or near the rock bottom at about 7 feet 6 inches from the face (except where the trench is narrow towards the ends, and where

the pipes are in the middle) to drain the trenches to a sump from which a centrifugal pump was used to discharge the water into the temporary trough carrying the river water. Vertical 4-inch pipes were brought up in the concrete at convenient intervals, to take off surface water from the face of the work, and a 6-inch pipe was afterwards laid to a gradient of 1 in 100 at a higher level in the work for the same purpose. Only in one instance was it deemed needful to bring up a vertical pipe from the foundation, where a small spring occurred in the ground near the fault, and as the work proceeded the water ceased to rise in the pipe. The water came into the trenches mostly at the level where the drift meets the solid ground.

The trenches, both east and west of the overflow, taper in plan from a width of 48 feet at the side of the overflow to a width of 15 feet 6 inches, which width is carried on to the ends of the embankment, and are then gradually reduced to 3 feet 6 inches which narrow width is continued to the end of either side.

The timbering of the trenches has been done by the ordinary method of polling boards in settings 3 feet apart, struts 12 to 13 inches square, walings 12 by 6, polling boards $1\frac{1}{2}$ and 2 inches thick. The struts were 8 feet 6 inches from centre to centre, giving a clear space of 7 feet 6 inches for the lowering of the materials. A good deal of the ground consists of loam and loose debris, with some running sand above the marl; and hence it has been found quite impracticable to remove the polling boards for a considerable length of the trench both on the east and west side.

The concrete below the original surface of the ground is either Portland cement concrete or Aberthaw pebble lime concrete, the former only being used for a limited thickness over the rock foundation and up the water face.

All the concrete is made by adding broken stone to previously prepared fresh mortar, the mortar used for concrete and for masonry being identical.

The mortar is composed of rock sand and Aberthaw pebble lime, or Portland cement, as the case may be. No sand is allowed except that prepared by crushing sound pieces of clean carboniferous limestone rock by machinery to pass through a sieve having square meshes $\frac{3}{16}$ inch in the clear, the finer particles being left in. For cement mortar the sand is mixed

by machinery with the Portland cement in the ordinary way For lime mortar, the Aberthaw pebble lime is brought in covered wagons to the mixing shed, slaked in batches, and passed through a hopper to the burr stone mill on the floor below, where it is ground between the revolving upper stone and the nether stone with the addition of water to reduce it to a hydrate of lime of the consistency of thick cream which is conveyed by Archimedean screw to the bins, from which it is measured out in the proper proportion and put in the mortar-mixer with the rock sand.

The proportions of the Portland cement concrete are—4 parts of broken limestone to 1¾ of mortar consisting of 2 parts of rock sand to 1 part of cement; and of the lime concrete 4 parts of broken limestone to 1¾ of mortar consisting of 2½ parts of rock sand to 1 part of hydrate of lime. And in all cases no other stone except the carboniferous limestone is allowed to be used for concrete, which stone is carefully washed before being brought to the crushing shed, there to be crushed to 2½ inches maximum dimension with all the smaller sized particles, including the dust, left in, the proportion of smaller particles being considerable, and of high value in the concrete.

Before any concrete is proceeded with on the rock or hard marl bottom, the surface is cleaned and washed by means of hose pipes and jets of water from a head of 100 feet until it is perfectly clean. Mortar is then spread in a thin layer, and brushed well into the interstices, after which the cement concrete is spread in a 3-inch layer and beaten down with specially designed iron beaters until the surface is brought to a plastic consistence, the concrete being brought on to the works in a semi-dry state. All the concrete is put on in layers of not more than 3 inches in thickness, and beaten down with iron beaters, and generally the rock bottom is covered with about a foot of cement concrete before the lime concrete is commenced. The covering of the concrete at the end of the day's work is done by spreading clean damp bags over the surface.

The Portland cement is required to be slow-setting and fine enough to pass "through a sieve of fifty brass wires per lineal inch, weighing about 3·36 ounces per square foot, through which at least 90 per cent. shall pass freely." Briquettes are made at discretion from each ten tons or thereabouts of one

square inch minimum section, and of five such briquettes one must after 7 days sustain without fracture a weight of four cwt. for not less than one minute. A temperature test is also made, and the rise in fifteen minutes is not to exceed 1° Fahr. or 3° Fahr. in one hour. The highest result obtained for a briquette of neat cement was a breaking strain of 849 lbs. per square inch.

TESTS OF LIME MORTAR BRIQUETTES OF 1 SQUARE INCH MINIMUM SECTION.
Proportions, 2½ Rock Sand to 1 Lime Hydrate.

Age of Briquette when Tested: Months.					Sand used.	Remarks.
2	4	6	12	18		
Breaking Strain in lbs. per sq. in.						
Tension Tests.—A.						
94	262	315	301	..	$\frac{3}{16}$	Mortar from burr mills too wet for briquette making.
86	127	221	344	..	,,	
50	119	154	330	..	,,	
26	95	..	313	..	,,	
72	128	..	280	..	,,	
39	83	150	273	..	,,	
67	157	200	293	..	,,	
50	137	141	242	..	,,	
Tension Tests.—B.						
76	157	256	372	397	$\frac{3}{16}$	Lime ground in hand mill, and used as mortar of suitable consistency for briquette making.
82	240	415	519	..	,,	
124	235	295	305	..	,,	
184	333	354	408	..	,,	
222	410	428	546	608	$\frac{1}{8}$	
261	375	427	..	..	,,	
370	558	..	730	..	,,	
339	458	..	584	..	,,	
168	229	399	450	..	,,	
222	211	408	508	..	,,	
112	299	435	488	..	$\frac{3}{16}$	
75	187	391	..	..	,,	
Compression Tests.—C.						
Tons per square foot.						
35·7	65·38	88·12	..	..	$\frac{3}{16}$	Mortar from burr mills too wet for briquette making.
35·5	42·10	84·60	104·68	..	,,	
24·4	55·5	108·90	136·18	171·77	,,	Lime ground in hand mill specially dry for briquette making.
..	..	..	134·47	150·37	,,	

The testing of the degree of fineness to which the hydrate of lime has been ground is ascertained by placing a weighed quantity of the hydrate in a beaker, and by means of a thistle

tube conveying a small stream of water to the bottom of the glass, the milk of lime is washed over the top of the beaker, leaving a residue consisting of impurities and refractory particles, which residue is weighed and should not exceed 4 per cent. of the weight of the sample tested.

Briquettes for tension test and compression blocks of the lime mortar are made from time to time, and some of the results obtained are given in the preceding table. In order to obtain a high result in a short period, the mortar when made into briquettes must be very dry and too dry for practical use.

There can be no doubt that the Aberthaw lime, properly treated, makes an excellent mortar for hydraulic work, and it will keep on improving in strength for a long period. Its slow setting renders it unsuitable for placing where the action of running water goes on, but otherwise it is a safe and reliable cement if properly treated, and the mortar made in the manner described is tough and "gluey." Experiments have been made with mortar prepared by sieving through fine sieves without grinding (2500 holes per inch) carefully slaked lime, and adding to it sand in the proportion stated; and some results are as follows:—

Tension Tests.—D.

Age of Briquette when Tested: Months.			Sand used.	Remarks.
2	4	6		
Breaking Strain in lbs. per sq. in.				
151	338	..	$\frac{1}{8}$	Lime used as mortar of suitable consistency for briquette making.
154	230	291	$\frac{3}{16}$	
52	120	234	"	
208	..	420	"	
199	262	320	"	
107	235	354	"	
199	344	408	"	
153	268	341	"	
73	128	247	"	
187	297	442	$\frac{1}{8}$	
75	195	270	"	
170	311	435	"	
127	165	370	"	
141	275	297	"	
344	382	..	"	
392	..	474	"	
320	..	515	"	

The average tensile strength of six months of the mortar made with lime sieved through 2500 meshes to the square inch is thus 340·7 lbs. per square inch, while the finer comminution produced by the burr stones (see Table B) gives a strength of 380·5 lbs. It must not be forgotten, moreover, that in the sieving method some of the best part of the hydraulic lime is liable to be lost.

The stone for the masonry as well as for the concrete and rock sand is obtained from a quarry of carboniferous limestone situate about seven miles from the site of the works and belonging to the Dowlais Iron Company. It is conveyed by rail to Torpantau Station and thence along the temporary railway. Blocks of great size are obtainable, but the limit of weight for the stone used is governed by the capabilities of the machinery. A large proportion of the stone used in the dam weighs from two to six tons. The stone is very hard, and its weight per cubic foot is about 169 lbs. Both the water face and the outer face consist of heavy rough broken work, the outer face of the overflow portion having a liberal projection of rock. All the face stone is roughly squared to a pitch line, and the joints are not less than ¾-inch thick bedded in a thick layer of lime mortar spread with shovels. After a certain height of the water face has been built, the caulking of the joints is proceeded with, the mortar in the joints being driven back by proper tools and more mortar added in a semi-dry condition, the joint being brought out and finished perfectly flat within not less than ½ inch of the pitch line. The hearting consists of large blocks of stone, having a good flat bottom bed, placed near to each other and well bedded on a thick layer of mortar, the stones being well sunk down into the mortar. The spaces between the blocks, although of an irregular shape in plan, are fitted to break joint, and filled with concrete, and where large enough rubble stone is packed in, punners and iron tools of various shapes being used to fill in all the spaces tightly and to bring up the surface to form a proper bed for receiving the next layer of mortar. The quantity of mortar and concrete required for this kind of heavy masonry is nearly 40 per cent. Only the face of the work is set by masons, the hearting being done by labourers. The weight of a cubic foot of masonry is about 158 lbs.

The lower part of the dam at the overflow where the width

of the foundation is about 100 feet, was built by means of two high overhead steam travellers, running on high gauntrees across the dam of 50 feet span, capable of lifting 6 tons, and two steam travelling cranes, one 5 tons, and the other 3 tons, running alongside the travellers, the length of the work commanded by the four machines being about 150 feet, the materials being brought down to the bottom of the gauntrees by rail and tramways. After the work had been brought up to near the level of the gauntree, a high level gauntree was constructed along the outer face of the dam joining the temporary railways at the east end, carrying the 4 foot 8½-inch road, from which the travelling cranes can reach across the width of the dam at that level (about 17 feet below top water). Four travelling steam cranes run on this road, capable of lifting 5 tons, 3 tons, 2½ tons and 2 tons respectively, at a radius of 16 feet, and a further steam crane lifts the mortar and concrete to a 2-foot gauge road on the same staging, whence it is taken as required. There are movable platforms on the dam with chain attachment, upon which concrete and mortar are deposited. All the concrete and mortar is fed automatically into iron side-tipping wagons, the body of the wagon being lifted from the frame in the bottom and dropped into a similar frame on the top. The cranes and overhead travellers were made by Smith, of Rodney, near Leeds.

The stone-breaking shed is a two-storied building so arranged that both the stone for concrete and the rock sand can be discharged into wagons automatically. A "Baxter's" 16 by 9 and a "Mason's" 15 by 8 produce the stone for the concrete. For sand producing, the stone is first broken by a "Robey" 12 by 8 machine to about 2-inch gauge, and this machine supplies a sufficient quantity to feed the "Marsden" 20 by 3-inch, "Baxter" 12 by 3-inch and "Robey" 12 by 3-inch pulverisers. The sand from all these machines is carried by a conveyor to one end of the bottom floor, whence it is elevated into a hopper from which the wagons are loaded. The machines are driven by a locomotive converted into a stationary engine, having 12-inch cylinders by 18-inch stroke, running 150 revolutions per minute. This plant will turn out about 80 cubic yards of concrete stone, and 30 cubic yards of sand per day of ten hours.

The mixing shed, placed near the site of the overflow, con-

tains storage room for cement and lime, cooling floors for cement, slaking bins for lime, grinding machinery for lime and bins for the hydrate and concrete mixers, &c. The burr mills for the lime are three in number, two of 4 feet 3 inches diameter and one 4 feet 6 inches, running at about 140 revolutions per minute, two of which are generally in use and the third being dressed. There are two concrete mixers and one mortar mixer, of the horizontal bladed type, made by Sir William Arrol, the blades being set at an angle, and one mortar machine, which is similar to a horizontal clay pug mill.

The contractors have also a fitting shop containing a 10-inch lathe, drilling machine, a saw bench and two forges, driven by a portable engine, and at the limestone quarry, a heavy 15-ton travelling crane, with 60-foot jib, and a 3-ton travelling crane.

Two locomotives deal with the materials from the Torpantau station, and fifty ballast wagons have been in use to convey the stone and other material.

It may be mentioned that this is only the second dam constructed in this country in which the cementing material is mainly hydraulic lime mortar. The Kendal (Fisher Tarn) Reservoir was the first. The valves were closed in February last at the Kendal Reservoir, and the water is now within a few feet of the overflow. I understand from the engineer, Mr. Deacon, that the dam is quite watertight. The lime was obtained from the neighbourhood of Warwick, a different part of the great outcrop of Lias lime running across the country from N.E. to S.W. from that from which the Aberthaw pebbles are formed on the south coast of Glamorgan. It was manipulated at Kendal in the same manner as at Merthyr.

NOTE.—Since the paper was written, tests at the end of two years of two lime mortar briquettes in the table marked "Tension Tests A," page 55, have given 451 lbs. and 426 lbs. respectively, showing an increase in the breaking strain in the one case of 190 lbs. and in the other of 96 lbs. during the second year. The later tests, at regular intervals of time, of the briquettes given in the other tables show also a steady increase of strength.

DISCUSSION.

Mr. G. F. Deacon: I beg to move a vote of thanks to Mr. Harvey for the very excellent paper which he has been good enough to present to us. I would venture to remind the meeting that this is the twenty-first anniversary of the formation of the Western Counties and South Wales District—South Wales having since become a separate district. In that same year I was President of this Association, and in my address said certain things respecting the future of the Association which I am glad to say have come true.

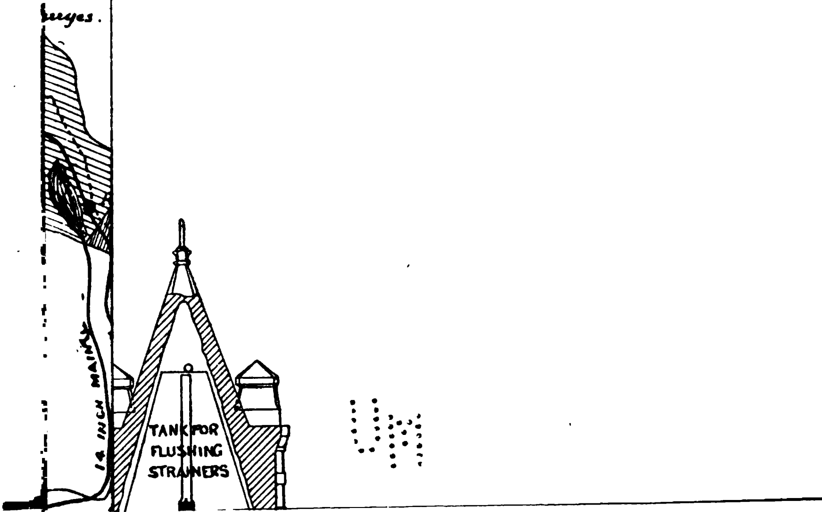
I pointed out, what our President has always so pertinently said, how excellent a thing it would be for the corporations and councils of the country to give every encouragement to their engineers and surveyors to see the works of others and not to confine their practical knowledge within the limits of their immediate surroundings.

Mr. A. H. Priestley: I have listened with much pleasure, as I am sure all the Members have done, to the very interesting paper Mr. Harvey has read, and it gives me great pleasure to second the vote of thanks Mr. Deacon has so ably proposed. There is only one question I wish to ask. I should like to know how the water is conveyed to the tank in the tower—whether it has to be pumped or not.

Mr. J. Williams: I should like some explanation why this foot of cement concrete is put immediately upon the rock while the remainder is lime concrete. I am convinced that an explanation can be given, but it occurs to me that it is the formation of a plane of separation between the two makes of material. Then there is a reference in the paper to special running tools. Will Mr. Harvey give us some idea what those tools are like? I should also like to know why they are bringing limestone from a great distance for this work when there is sandstone in the immediate district which could be used for the work. Is it that the limestone is believed to be more suitable than the sandstone which might be obtained in the district? Then are these rough masses of masonry in the hearting used in preference to concrete because they are cheaper or because they are thought to be better suited for the work? It has occurred to me that, if concrete is cheaper, there must be some special reason for introduc-

E MERTHYR WATERWORKS.

T. F. HARVEY.



ing the masonry. The excellent results of the test of Aberthaw lime are very interesting.

Mr. T. H. Yabbicom : I should like to give my thanks to the Author of this paper for the very valuable results of the tests make by him on Aberthaw lime. I can also bear testimony to the great value of this blue lias lime for hydraulic work when burnt from the clean pebbles from the beach at Aberthaw, and refer to a very practical experience, not of my own but of other persons, of a forty years' test of mortar made with the lime under consideration. My predecessor graduated at Neath; he, therefore, had a very large experience of Aberthaw lime, and brought that experience to bear on drainage work at Bristol forty years ago. The mortar was made from lime burnt from the clean pebbles ground with furnace ashes, not sand. I had occasion some time ago to remove a portion of the sewer so constructed, and in cutting into the brickwork found that the bricks broke before the mortar joint. In the case of a sewer with a very steep gradient the bricks had scoured away before the mortar. A practical test of that kind is even more valuable than an academic test you may get from the laboratory, and proves the great value of Aberthaw line for hydraulic work.

The President : What kind of bricks are you speaking of?

Mr. Yabbicom: They are a local brick, made principally from marl.

Mr. Deacon: They are not blue bricks?

Mr. Yabbicom : No, a local brick, but a brick that stands a considerable amount of pressure.

Mr. F. Orton : I should like to ask whether any difficulty was experienced in taking out the timber from the trench. In the neighbouring valley of the Taff Fawr, we passed through a considerable quantity of running sand, and there we had great difficulty in taking out the timber. This was accomplished by building up brick pillars on each side of the trench to support the weight of the timber above. The timber was then taken out without further difficulty, and when solid ground was reached and the pillars were no longer required they were finished off with a cone-shaped top so as to allow the puddle to settle uniformly.

We also met with several springs in the trench which were collected from both sides of the trench, and conveyed through 3-inch pipes laid in the concrete shoe, to a sump hole. At the

deepest part of the trench (about 27 feet below the old river bed) valves were connected to the pipes in the sump hole, and a brick chamber about 5 feet square built up in advance of the puddle to accommodate the pumps. When the puddle was high enough to allow the springs to gravitate to the main drain the valves were closed, the sump hole pumped dry, and the pumps removed. The sump hole and chamber, after being cleaned out, was filled with cement concrete.

Mr. DEACON: The sump hole was on the down-stream side of the puddle?

Mr. ORTON: Yes, though the springs were collected from each side of the trench.

PRESIDENT: But they were conveyed to the down side?

Mr. ORTON: Yes.

Mr. DEACON: Do not the springs continue to be connected to the main drain?

Mr. ORTON: Yes; I may add that the springs from the lower side are now practically dry, but those from the upper side remain much about the same as they were before the reservoir was filled.

Mr. COX: I should like to ask whether the designers of the work are satisfied that Aberthaw lime is a safe material to use in the construction of a reservoir dam? I ask this question because Aberthaw lime is the material which has been used in the construction of a small reservoir in my district, and the lime is as loose now as the day it was put in ten years ago. Therefore, I should like to know whether they are satisfied that Aberthaw lime will set when surrounded by water.

Mr. WYRILL: I should like to ask why the local stone was not used on this work. Probably there is some good reason for that decision which does not appear on the face of the paper. A question has been asked as to the reason for putting a foot of cement concrete on the base of the stone, and it has been described as a plane of separation between two bodies of limestone. I think the geology of the district is rather different from that. As I understand it the dam is based on the Old Red Sandstone. With reference to the section of the dam, there are no dimensions given, but from a casual look at the plan, the profile of the dam appears very light. The only question of stability referred to in the paper is that the power of resistance comes mainly in the middle third of the dam.

Could we obtain the intensity of the pressure with the reservoir full and the reservoir empty? It might be useful to have this, because this is an Aberthaw lime dam, and other cement dams are Portland cement dams, and the power of resistance is well known.

Mr. WILLIAMS: Mr. Wyrill quite misunderstands my point. My question was not that there would be two lime strata together, but that there would be on the top of the Portland cement stratum a lime cement stratum, thus causing a plane of separation between two artificial bodies of a different nature, and not so likely to form one homogeneous mass.

The PRESIDENT: There is one point in the paper which struck me as being a wise course on the part of the Merthyr Council—that is the building of the embankment of the reservoir by their own labour. I think that has become the practice, almost universally, with all large reservoirs, and there is no doubt it will add to the permanent success of reservoir work. The supply of materials, etc. by contract is a different matter, but the carrying out of the actual work of construction by direct labour appears to me to be the proper course. We found in the building of the reservoirs for Cardiff, in the Taff Fawr Valley, parallel to the valley we are about to meet, that that was the only course we could adopt; the Merthyr Council have adopted it in this case, and it has also been adopted in several other cases in which Mr. Deacon has been the engineer.

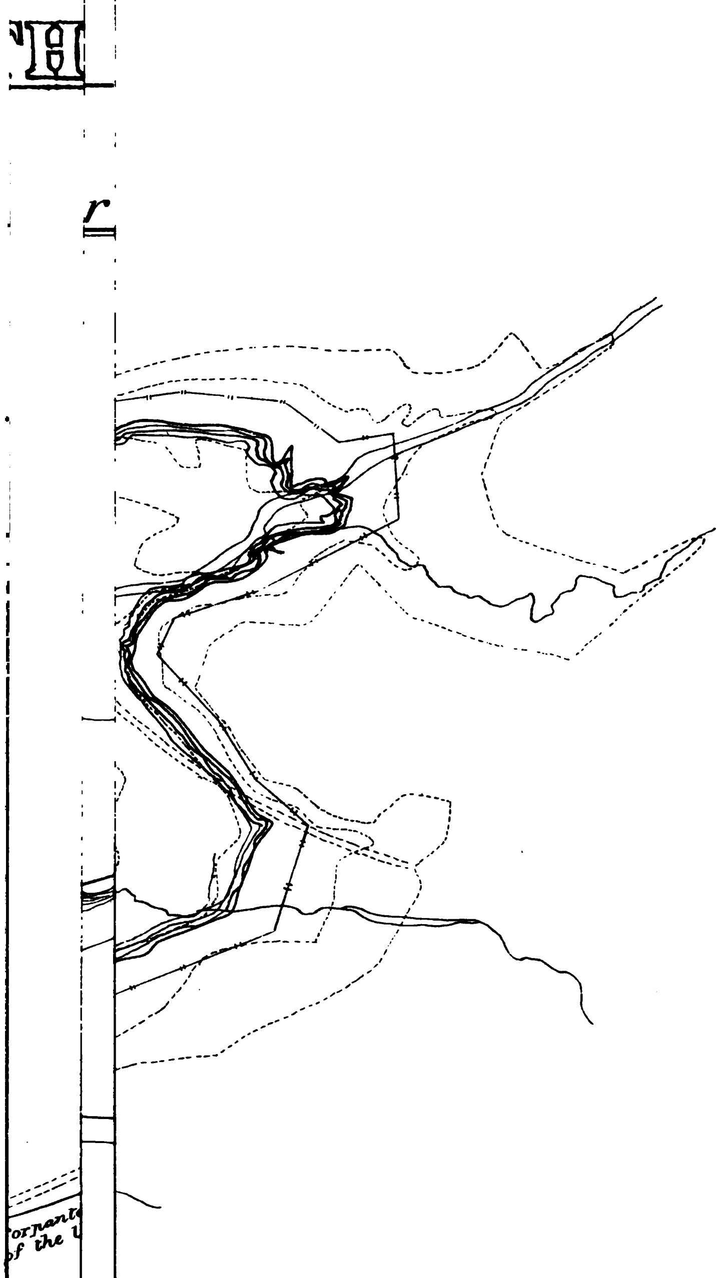
The vote of thanks having been carried by acclamation,

Mr. HARVEY, in reply, said: I am much obliged for the kind vote of thanks proposed to me, and I think it comes with peculiar grace from Mr. Deacon, with whom I have been associated in the carrying out of this work for some time. With reference to the questions which have been asked, Mr. Deacon, who designed the works and is the engineer, being present, will no doubt offer some supplementary remarks to those I shall make. The water will be conveyed to the tank in the tower by gravitation; only a small quantity of water being required, which will flow from a rill on the hill side. The use of limestone for making mortar and concrete, and for the masonry in preference to the other stone of the district, was determined partly by experiment and partly by practical knowledge. First of all the weight of the limestone is rather more than that of the Old Red Sandstone. Secondly, the experiments conducted by

Mr. Deacon showed that the mortar briquettes made with crushed limestone sand gave a higher tensile strain than those made from sand produced by crushing the Old Red Sandstone. For this dam, moreover, the limestone is really as cheap as the sandstone, and probably cheaper, but if it had not been so, the limestone was proved to be the better. The reason the layer of concrete was put in at the bottom on the rock foundation was practically answered in the paper. The cement concrete is used over the bottom and up the water face for a certain height only, because it sets more quickly than the Aberthaw lime concrete. It was desirable to start the main body of concrete as quickly as possible, and by putting over the uneven rock foundation a layer of Portland cement concrete, we were able to proceed with the lime concrete upon a bottom which was thus brought up to a comparatively dry and even surface. The lime concrete was often put on the cement concrete before the latter had set hard. When the cement concrete had got hard the surface was scored and grooved, so that there should be a proper joining of the two together. The roughing and grooving of the surface also applies to the lime concrete when a new layer is started upon old work set hard.

The next question was as to the special punning tools. These will be seen at the works. It may be interesting to remark that for one of the tools, viz. the beater, a new word was coined: the word beater did not "take on" with the men, and they substituted for it "ding bat," calling those who use it "ding batters." The sound of many of these heavy tools beating the concrete at the same time no doubt originated the new name. The question has been asked why limestone was brought from a quarry situated a few miles away instead of using the sandstone on the ground. I have already given some reasons, but omitted to state that there were several trials made on the ground for Old Red Sandstone, and it was found to be difficult to get a quarry that would produce at a reasonable cost such large quantities of good stone as were required. As to masonry being used in the hearting of the dam instead of concrete, the question would almost seem to suggest that the whole dam should be of concrete. As a matter of fact concrete hearting would have been more expensive, and not so good. When the Members visit the dam they will see that the concrete has been used only from the foundation to near the surface of the ground, and afterwards

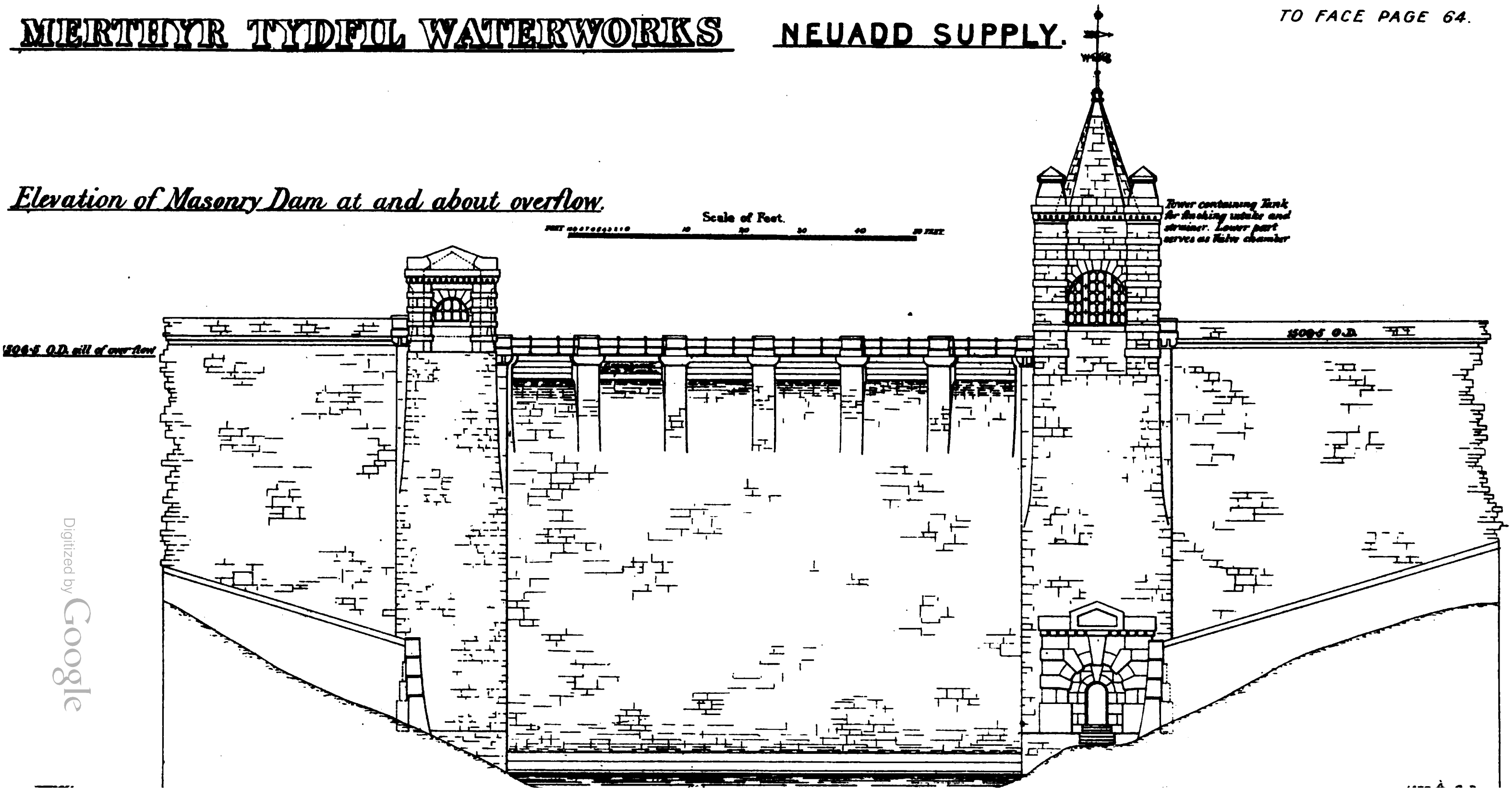
TO FACE PAGE 64.



George F. Deacon
Engineer
Westminster.

MERTHYR TYDFIL WATERWORKS NEUADD SUPPLY.

Elevation of Masonry Dam at and about overflow.



we began building the masonry structure. I was interested in some remarks that fell from Mr. Yabbicom, as to old mortar made from Aberthaw pebbles. I have been very much impressed for a long time with the value of Aberthaw lime, and there is no doubt if it is prepared in a proper way it is a most excellent material. The work constructed with Aberthaw lime, referred to by Mr. Cox, which was loose after ten years, must have been improperly done; for with properly prepared hydraulic lime concrete or mortar, such a thing could not possibly have happened. As to the question of Mr. Orton with respect to the removal of the timber, I have stated in the paper that the timbering is of the ordinary description with vertical polling boards, 3 feet long. It is not so easy to remove in bad ground as the horizontal method of timbering. The ground here and on the Taff Fawr is very similar, though we have perhaps had less running sand to deal with. I think I have said that in the low part of the trench there was a sump on the water face of the dam. A centrifugal pump was used to discharge the water across the face into the river. There came a time when that connection with the sump could be done away with and the pipe leading to it could be sealed. The drain exists, and is connected with a drain at the higher level, which passes into the compensation culvert. With respect to the question asked in regard to the section of the dam and other matters, Mr. Deacon is good enough to tell me that he will make a few remarks in reply.

Mr. Priestley: I should like to ask what the reason was for the Council employing a contractor for part of the work and doing the other part themselves—especially as they commenced by laying the railway down.

Mr. Harvey: That is a question which naturally occurs to one, and was discussed between myself and Mr. Deacon for a good while. I think the few words I said on the subject in the early part of the paper make it almost clear. Practically it means this: that work done by contractors is often turned out more cheaply—I do not say it ought to be so—than work done by administration, and the work done in this case by the contractor is work that can *safely* be done by a contractor. Another reason was the large amount of money that would have had to be expended by the Council in plant if they had undertaken the whole of the work. What we did was to take care that the

whole of the building work should be done by the Council's men, involving only a small outlay on plant, and thus that the most important part of the work should be carried out by administration.

Mr. Priestley: That does partly answer my questions as to why did you not undertake the whole of the work. Your answer as to plant I take it is the chief reason why you did not do so.

Mr. Harvey: The cost of the plant and the opinion that the sinking of the trenches and other work would be more costly by administration than if carried out by contract.

Mr. Orton: I should like to support what Mr. Harvey has said relative to crushed limestone. I have had several briquettes made of cement mixed with crushed limestone and cement mixed with sharp Bidford sand. When these were tested those mixed with crushed limestone stood a much greater tensile strain than those mixed with Bidford sand.

Mr. G. F. Deacon: On the point raised as to the strength of concrete and mortar made with crushed limestone as sand, there can be no question whatever; thousands of briquettes have been made and broken for its determination. However well river sand may be washed you cannot get rid of the fact that the surface of each grain is to some extent decomposed by the action of time, and does not adhere to the cementing material so well as the newly broken particles of a clean rock. This advantage of crushed rock over natural sand is not confined to limestone, but so far as my own observations go limestone gives the highest result.

Then as to the use of masonry *versus* concrete for the construction of any important—more especially water-tight—work above ground. I would ask if any Member has ever seen a concrete wall 1400 feet long without cracks in it. We should not be sanguine of being able to construct such a wall without cracks appearing, if not initially, at least after a time, as the result of expansion and contraction; but we do believe that the masonry of the upper Neuadd dam will have no cracks in it. The expansion and contraction of concrete by changes of temperature is greater than that of stone, and the secret therefore is to get as much stone as you can into the work. Moreover, the volume of the concrete would have to be much greater than that of the masonry as its density is much less. With regard to the use of

hydraulic lime as distinguished from Portland cement I have to point out one property which has not yet been mentioned, viz. that the permanent elasticity of hydraulic lime concrete and mortar appears to be greater than that of Portland cement concrete and mortar. That property is of more importance than strength in works of this kind. The mere strength of either material is much greater than we require for masonry dam building until the height of the structure exceeds anything yet proposed. The question of mixing lime concrete with furnace ashes has been mentioned. Such a mixture makes excellent mortar for most purposes, but it is light mortar—deficient in density—and for such work as a masonry dam it is important to secure the greatest possible weight. It has been mentioned by Mr. Wyrill that the section of the Neuadd dam looks light, but perhaps he has not noticed that the central portion is a horizontal arch, and that in the immediately adjoining sections there is considerable weight of masonry above the water level, while the sections more distant from the centre are not dependent wholly upon their weight, but upon that weight combined with the earth resistance which at the extreme ends is effective up to the water-level, so that the dam is there a mere diaphragm. The resultant pressure on the base is everywhere well within the middle third, and the dam is really stronger than many so called pure gravity dams. I was surprised by the statement that Portland cement had been the material hitherto used in masonry dam building, and that the calculations relating to the stability of dams had been based upon the use of that material. The contrary is the fact. I have records of some sixty-six finished masonry or concrete dams in various parts of the world, and of these I believe only about eight are constructed with Portland cement. The construction of these eight Portland cement dams has I think taken place since the publication, but has certainly not been the result of the mathematical investigations of the French writers M. Graeff and M. Delocre, which appeared in the 'Annales des Ponts et Chaussées,' or of the classical report subsequently made (in 1871) at the instance of the Bombay Municipality by the late Professor Macquorn Rankine, F.R.S. From the instructions for the preparation of that report it appears that rubble masonry with a fairly hydraulic (natural) lime and hard trap rock was to be used. That report has been the foundation of all that has been done since. Except in connection with matters

with which it did not profess to deal, no important advance has since been made, and, as a matter of fact, the Vyrnwy dam—144 feet to the water level—is the only high dam as yet completed with Portland cement as the cementing material. In saying this I say nothing against the use of that most excellent material; but it is not necessarily better than properly treated hydraulic lime, except where running water is liable to be met with during construction, or where great stresses are to be resisted very shortly after construction.

One speaker had evidently been unfortunate in the use of hydraulic lime. We have heard such stories before, and not only about lime but about Portland cement also. The truth is that both these materials require certain precautions and manipulation after being received from the burner or manufacturer as the case may be. Portland cement requires keeping until the atoms of free lime are reduced to hydrate of lime by exposure to the atmosphere. Hydraulic lime requires more consideration still to reduce the refractory elements of lime which, though they are stronger as a cementing material than the quicker slaking portions, refuse to slake while the bulk of the lime is slaking. The process of slaking of such particles, however, is only deferred, and if the bulk of the material has already set, the expansion caused by the subsequent slaking of a portion may disintegrate the whole. Obviously, therefore, the refractory particles must either be removed or they must by some means be encouraged to slake at the same time as their yielding neighbours. With proper manipulation there is no difficulty in securing perfect safety either with Portland cement or hydraulic lime. Of this you will see abundant evidence when you reach the works.

One other matter referred to in the paper I should like to say a word upon. Local engineers too often depend upon the records of single rain gauges to determine the mean rainfall over large areas. In no case is this a safe thing to do. The difficulty of so placing a single gauge as to record the average rainfall over a mountain area of one or two thousand acres is extreme. I will give you an example. The original gauge at Neuadd was just to the N.N.E. of a slope facing S.S.W. After inspection I believed that all the records of that gauge were much too low, even for the immediate neighbourhood. We accordingly, without disturbing the existing gauge E, fixed

thirteen more gauges in a straight line running S.S.W. and N.N.E. of the existing gauge. Without entering into a full analysis of the records of these gaugings, I will say shortly that after three years the gauge D, 71 feet S.S.W. of the original gauge E had recorded 19·9 per cent. more rain than E, while the gauge G, about 160 feet N.N.E. of E, had recorded 14·2 per cent. more. In one year the excesses were 20 and 14·1 per cent. respectively, and in a particular month they were 61 and 19·8 respectively. The cause of these remarkable differences is simply the fact that gauge D was on the slope of 1 to 1½ facing S.S.W. The original gauge E, 81 feet away, was 40 feet beyond the top of this steep slope and upon another slope of 1 to 6 in the same direction, while gauge G, 160 feet further in the same direction, was upon the general slope of the ground, about 1 in 12. When the prevailing winds blew towards the slopes the current of air striking the steep slope was projected upwards, while the raindrops, already falling in an inclined path, were compelled on reaching this current to assume a more inclined path, sometimes possibly an almost horizontal path, for some distance beyond the top of the steep slope. It so happened that gauge E was within the sphere of rainfall thus reduced, and did not represent the mean. Such cases were very common. It is important to note the enormous percentages of variation in particular months, obviously caused by the greater prevalence of particular winds in those months.

But even with the best knowledge and judgment it is not safe to depend upon a single gauge, and when good certified gauges can be purchased for 15s. or 16s., there is no excuse for doing so. They should not be placed on local flats or near local changes of level, but on such slopes as represent the general inclination of the ground for a considerable distance on all sides.

The Members then proceeded by special train to Torpantau, and were met at the station by the contractor's train, on which they were carried along the railway to the works. On arrival at the works, luncheon was served in the Mission Room, the High Constable and Chairman of the Merthyr Urban District Council, Mr. J. Owen, J.P., presiding. The remainder of the afternoon was devoted to an inspection of the works in progress, especially the masonry dam.

DISTRICT MEETING AT CARLISLE.

May 26, 1900.

Held in the Town Hall, Carlisle.

W. HARPUR, M. INST. C.E., PRESIDENT, IN THE CHAIR.

THE Mayor (Councillor C. Ling, J.P.) received and heartily welcomed the Members to the city.

The PRESIDENT said he had thanked the Mayor and Corporation of Carlisle for so heartily receiving the Association. It was not the first time the Association had visited Carlisle.

Mr. DALTON, the Honorary District Secretary, read the minutes of the last Northern District Meeting at Whitehaven, which were confirmed.

Mr. F. BAKER proposed, Mr. BRODIE seconded, and it was carried unanimously, that Mr. Dalton be re-elected as Honorary District Secretary for the Northern District.

The PRESIDENT then reported to the meeting the sad news of the death of Mr. Edward Pritchard, Past President.

A vote of condolence with the widow and family was passed in silence.

SOME OF THE PUBLIC WORKS IN CARLISLE.

BY HENRY C. MARKS, ASSOC. M. INST. C.E.,
CITY ENGINEER AND SURVEYOR.

THE present is the third occasion on which the city of Carlisle has been honoured by a visit of this Association. The first of these meetings was held here in 1883, under the Presidency of Mr. W. G. Laws, city engineer of Newcastle-on-Tyne, Mr. H. U.

McKie at that time holding the office of city engineer of Carlisle. The second meeting was in 1888, under the Presidency of the late Mr. Joseph Gordon, Mr. McKie still holding the position of city engineer.

During the somewhat long period that has elapsed since the last visit of this Association, the Corporation of Carlisle has displayed much energy in its public works.

It might be interesting to many of the Members if, before describing the public works, a brief outline were given of the history of this very ancient city. The Bishop of London (a native of Carlisle), in his History of Carlisle, says, "No English city has a more distinctive character than Carlisle, and none can claim to have borne its character so continuously through the course of English history. Carlisle is still known as the 'border city,' and though the term 'the border' has no longer any historical significance, it still denotes a district which has strongly marked peculiarities and retains a vigorous provincial life.

"This, then, is the distinguishing feature of Carlisle; it is 'the border city.' But though this is its leading characteristic, which runs through all its history, it has two other marks of distinction when compared with other English towns. It is the only town on English soil which bears a purely British name, and it is the only town which has been added to England since the Norman Conquest.

"The survival of the British name of the town shows that it was in early times a place of some importance. Caer Lywelydd, the town of Lywelydd (whether this was a tribal, or local, or personal name it would be hazardous to say), still bore its old name in altered shape through Roman and English occupation, and Luguvalio, Lugubalia, Caerluel, Carliel, Carlile, Carlisle are only phonetic variations of the earliest form."

In the past Carlisle has had within its walls many persons of fame and might. Agricola the Roman Consul and Hadrian the Roman Emperor visited Carlisle; Egfrith, King of Northumbria, visited it in the seventh century, also St. Cuthbert in the year 685 A.D. Halfdene, a Danish leader, in 876 A.D. laid the city in ruins, so that for 200 years it was a waste, and large oaks grew on its site. William Rufus, when he came northward with a large army, repaired the city of Carlisle, built the castle, and drove out Dolphin, who had previously governed the

country, and, having placed a garrison in the castle, he returned south and sent a great number of English husbandmen thither, with horses and cattle, that they might settle there and cultivate the land.

It appears from ancient records that Carlisle was spoken of as a borough as early as 1159. The earliest charter of which anything is known was granted by Henry II.

Edward I. visited Carlisle on several occasions, and held two Parliaments, the first in 1298 and the second in 1307, when it is said the city entertained a throng of noble visitors such as it had never held before. This king died at Burgh Marsh, 6 miles from Carlisle, where a monument still marks the place. Mary Queen of Scots was removed to Carlisle Castle in 1568, where she remained for some weeks. Prince Charles Edward's troops besieged and took the city in 1745, and on November 16 in that year, the mayor and corporation attended in state while King James III. was proclaimed at the market cross. On the 18th, they again assembled to greet the prince as he entered Carlisle, mounted on a white horse and preceded by a hundred Scottish pipers. Prince Charles Edward finally left the city on December 21; the city was again taken by the King's troops on the 30th, and the first act of the Duke of Cumberland, who commanded, was to order into custody the mayor and town clerk and eight other citizens, for having surrendered the city to the rebels.

From this date Carlisle seems to have had a more peaceful period and to have been able to devote time to the improvement of the city and her citizens. The population, which was only 2000 in 1720, rapidly increased according to the following table :—

1801	10,221
1861	29,417
1891	39,176
Estimated at present . . .	42,500

Before quitting the ancient history of the city, it is of interest to recall the fact that the Bishopric of Carlisle was founded in 1133 by King Henry I., the first bishop being Athelwald, who before his appointment to Carlisle occupied the post of Prior of St. Oswalds, at Nostel, in the West Riding of Yorkshire.

Coming to more immediately modern times, Carlisle is now one of the principal railway centres in the country, it being the terminus of no less than four English and three Scotch railways, namely, London and North Western, Midland, North Eastern, Maryport and Carlisle ; Caledonian, North British, and Glasgow and South Western.

Passing now to the immediate objects of this paper, namely, the principal works which have been carried out or are contemplated in the City Engineer and Surveyor's Department, the following may be enumerated.

Electric Lighting.

In 1883 the Corporation of Carlisle decided to apply for a provisional order to enable them to supply electric current within their city ; the council were, however, not satisfied that the system of electric lighting was sufficiently developed to justify them in spending the money of the citizens in introducing it. Nothing was therefore done, and the order was allowed to lapse. In 1895 the Corporation thought that the great improvements which had been developed in connection with the public electric installations would justify them in again taking in hand the installation of an electrical plant. They therefore applied to the Board of Trade and obtained a second order, and in January 1897 they resolved to appoint an electrical engineer, and in the following month it was unanimously resolved to ask Dr. A. B. W. Kennedy, of Westminster, to design and carry out an electric installation for the city. Dr. Kennedy presented a report, and advised that plant should be provided which he estimated when fully equipped would cost 30,000*l.*

Early in the following year the Author was instructed by the General Purposes Committee to design the buildings for the generating station and office, and in March 1898 a tender was accepted from Mr. John Laing, of Carlisle, for the erection of these buildings at a cost of 7668*l.* 8*s.* 1*d.*, this being the lowest of seven tenders. The electric lighting station is situated near to the corner of James Street and the Viaduct, and consists of engineer's offices, store-rooms, storage batteries, engine room, boiler house, feed-pump room and tall chimney. The building has a frontage of 68 feet to James Street and a depth of 141 feet; the plans have been so designed as to provide for its

duplication when occasion requires. The front elevation is faced with Accrington pressed bricks and Shawk freestone dressings, and is set back 5 feet from the line of James Street, leaving an area which provides light for the basement. The whole of the area is surmounted above the street level by a dwarf wall with wrought-iron ornamental railings. The central portion of the building projects, and is finished with a pediment with balustrades at each side. The main entrance to the buildings, which has a semicircular arch over grey granite pillars, leads into the vestibule, the floor of which is laid with mosaic tiling bearing the city arms in heraldic colours, and the walls to dado height are finished with Burmantofts tiles. These buildings contain the clerk's and inquiry office, electrical engineer's office, deputy electrical engineer's office, drawing office, stores and necessary lavatory accommodation. In the basement provision is made for the storage batteries and fitters' workshop. From this building access is obtained to the engine room and switchboard by a flight of stone steps near to the engineer's private room. The engine room consists of a building 65 feet 6 inches long by 35 feet 6 inches wide; the floor is of concrete and the room is made perfectly watertight by patent asphalte linings, this precaution being necessary because the floor of the subways is below the flood level of the river Caldew, which skirts the site. The height from the floor to the wall plate is 28 feet 3 inches. The walls are finished in cream white glazed bricks, with coloured dado, and the building is entirely lighted from the roof, which is of light steel construction, the glazing being what is known as Messrs. Helliwell's patent glazing. The engine beds are formed of solid blocks of concrete 3 to 1, all other concrete 7 to 1, finish 1 quartz to 1 cement. The boiler house, which is situated immediately behind the engine room, is 75 feet long by 62 feet wide. Provision is made in this building for five boilers and two Green's fuel economisers. The boilers are seated on Poulton's patent seating blocks. This building is also below river flood level and is made watertight. The north wall in both the engine room and boiler house is of a temporary nature, as the present buildings only comprise half the complete design. The whole of the foundations of the buildings were taken down to and rest upon a good solid gravel bed, and it may be said that in neither the buildings nor the chimney has any visible settlement taken

place. The chimney stack is designed to suffice for the complete installation, which will then consist of ten boilers; the foundations are carried down 20 feet on to the gravel and consist of a concrete bed 26 feet square and 9 feet thick in the proportion of seven to one. It is carried up for 9 feet with solid brickwork. The inside of the flue is seven feet in diameter for the whole of its height. The chimney stands 160 feet above the ground level, the base being 16 feet square for a height of 24 feet; it is then gathered into a circular shaft and is surmounted by necking, cornice and stone coping. The inside of the chimney is lined with fire-brick for 100 feet in height, with a 4½ inch cavity between it and the solid brickwork. This cavity is ventilated from the external air by copper grids. The thickness of the brickwork of the chimney varies from 3 feet 6 inches at the base to 1 foot 6 inches at the top. The concrete block for this chimney was commenced on April 30, 1898, and the chimney was completed on November 3, 1898. It contains nearly 340,000 bricks.

The buildings were opened in May of last year, and the total cost was 7856*l*. 18*s*. 3*d*., which equals 4¾*d*. per cubic foot, without chimney, made up of 163*l*. 8*s*. for additional work not contemplated at the commencement, and 25*l*. 2*s*. 2*d*. extras on the original contract of 7668*l*. 8*s*. 1*d*. Although the buildings only came into use in May last, extensions are taking place in the plant, a description of the whole of which will be found in the paper which Mr. C. D. Burnet, the electrical engineer for the city, has kindly prepared for the information of this Association.

Tullie House.

One of the most important enterprises which has been carried out by the Corporation of Carlisle in modern times is that known as Tullie House, which has been described by the late Chancellor Furguson (in his guide to Carlisle) who was the Chairman of the Committee from its inception to the date of his death, which recently occurred. The Chancellor says:—

"This great pile of building, of which the citizens of Carlisle are justly proud, has for its nucleus a seventeenth century mansion house, whose front is in Abbey Street, though the entrance from that street is now generally kept closed. The

general entrance is in Castle Street, between the cathedral and the castle, and is easily recognised by its clock-tower, rising above the librarian's residence. The old house, Tullie House, an early instance of the classical revival, was built in the year 1699, as the dates on the fine lead spouts show, and probably by an elder brother of Thomas Tullie, Chancellor and Canon of Carlisle, 1684 to 1716, and Dean of Carlisle 1716 to 1726. The Tullies were a wealthy family in Carlisle, the descendants of one of the German miners, who were brought over in the reign of Queen Elizabeth to work the gold and silver mines at Keswick. Ultimately the house came nigh to being pulled down to make room for cottages; from this ignominious fate it was rescued by being purchased, in 1890, at the suggestion of Mr. C. J. Ferguson, F.S.A., by public subscription, together with a small property, a cottage, once known as the Punch Bowl public-house, giving access to Castle Street, for the sum of 3825*l.* The two properties and the balance of the subscription 676*l.*, were presented by the subscribers to the Corporation of Carlisle. The Corporation preserved the main part of Tullie House intact, but pulled down the kitchens and offices which were of more modern date, and on their site and in the garden made large additions to the original buildings, at a cost of over 22,000*l.* The foundation stone of these additions was laid on May 26, 1892, by B. Scott, Esq., then Mayor of Carlisle. The soil proved to be forced earth to a great depth, and teemed with objects of archæological interest, most of which may be seen in the museum of the building. At a depth of from 11 feet to 15 feet, according as the ground rises, a massive platform of triple oak planks, 6 inches thick, supported on massive piles and held together by iron nails 8 to 12 inches long, was found: it extended from Castle Street to Abbey Street, a distance of 220 feet, and its breadth was 40 feet. It has been conjectured that the platform was constructed by the Romans to carry a battery of ballistæ. The buildings, both new and old, were formally opened by J. A. Wheatley, Esq., then Mayor of Carlisle, on November 8, 1894, and the lending library was opened in February 1895."

The whole of the cost of this building has been defrayed out of current revenue, and it is now quite free of debt. The building provides a Public Free Library, Subscription Library, Public News Room and Reading Room, Reference Library, Science

and Art School, Art Galleries, Museum and Librarian's House. The whole of these works were completed before the Author was connected with the Corporation of Carlisle.

Carlisle Tramways.

In 1898, a provisional order was obtained by a private company for the construction of a system of tramways in the city and some of the suburbs. The company is entitled the City of Carlisle Electric Tramways Co., Limited. The works were commenced in September of last year by Messrs. Dick Kerr and Co., under the supervision, on behalf of the company, of Messrs. Pritchard and Dickinson, engineers. The system adopted being that of overhead electric traction, the permanent way is constructed of steel girder rails, 83 lbs. to the yard, laid 3 feet 6 inches centres upon a bed of cement concrete. The electric current is carried along the centre of the track in earthenware pipes; the trolley wire is in most cases carried by side poles and brackets, but in the wider streets permission has been granted to the company to erect centre poles. A car shed is being erected in London Road for the accommodation of the cars and workshops. The total mileage of single track which it is proposed to complete at present amounts to 8½ miles.

City Improvements.

Since the last meeting of the Association in Carlisle, a considerable number of street improvements have been decided upon, some have been completed and others are still in hand. The most important perhaps is that known as the extension of Lowther Street and Sand's improvement. This improvement was designed and practically completed during the surveyorship of Mr. W. Howard-Smith, and is generally admitted to be one of the greatest improvements that has been carried out in Carlisle, at any rate with perhaps the exception of the construction of the Victoria Viaduct. The cost of this improvement, together with the forming of Cattle Market enclosure, Newmarket Road, Hardwicke Circus and Bridgewater Road, amounts to about 31,000*l.*

Finkle Street has also been widened at a cost of 3385*l.* This was also carried out by Mr. Smith.

One of the first improvements which were carried out by the Author consisted of the demolition of a block of property which stood in the Green Market between the Town Hall and the Crown and Mitre Hotel. This widened the roadway in front of the Crown and Mitre from 24 feet 6 inches to 106 feet.

Another large improvement which is in hand is the widening of Bridge Street, Caldewgate. During the surveyorship of Mr. Smith a provisional order was obtained for the purchase of a large block of property for the purpose of widening Bridge Street from its present width of 34 feet to a minimum of 60 feet. After negotiating for some time, the whole of the property has been purchased by agreement, and it was reported to the Council on June 5th in last year, that the total cost of the purchase had amounted to 15,985*l.* Before the Local Government Board would allow this improvement to be proceeded with they required the Corporation to erect a certain number of dwellings for the labouring classes. These are now almost finished, and when completed will enable the Corporation to proceed at once with the improvement. In addition to the widening of Bridge Street a further improvement is now being negotiated for the widening of the bridges over the river Caldew and the Caledonian Railway. The present width is found to be quite inadequate for the constantly increasing traffic coming into the city from the west, and unsafe, owing to the steam arising from the railway traffic underneath. The Author has therefore advised that it is most desirable that this bridge should be widened to the same width as the improved Bridge Street, viz. 60 feet between parapets. Negotiations were opened with the Cumberland County Council, who are responsible for the bridge over the river and its approaches, the result of which is that the county authority have made an offer to pay to the city council a sum of 3000*l.* on condition that the Corporation take over the existing bridge and all its present and future liabilities. It is hoped that satisfactory arrangements may be come to with the railway company so that this improvement may be proceeded with at an early date.

In May of last year the Corporation resolved to purchase the necessary property for increasing the width of the south entrance to Castle Street from 27 feet 9 inches to 50 feet. In November the Corporation agreed with the owners of a large

portion of the land required, to pull down their premises and rebuild to the improved line, throwing 173 square yards of land into the street at a cost of 7000*l.* Negotiations are proceeding with the remaining owners, and it is hoped that the Corporation may be enabled to carry out the improvement without delay.

The Corporation have purchased at a cost of 354*l.* a block of dilapidated property covering an area of 177 yards at the entrance to the ancient castle, which they intend to demolish so as to improve the view of the historic keep.

In addition to these improvements the Corporation have paid 800*l.* to the North Eastern Railway Co. towards the cost of improving a bridge carrying their railway over Denton Street and for widening the road.

Negotiations are also pending with the North British Railway Co., for the construction of a new bridge carrying their railway over the Port Road, to increase the span from 24 feet to 40 feet.

In addition to the improvements to the town by widening of streets, which are becoming necessary owing to the increased traffic, the Corporation are taking every opportunity of improving the appearance of the town by the planting of trees, and using all available spaces for the growth of flowers and shrubs. Much has also been done to improve the Corporation lands known as the Bitts and Sauceries, shrubberies round the cattle market and various other parts of the city; and a further considerable improvement to the entrance to the city from the north has been made by the erection of a memorial to a leading citizen who took a very prominent part in the last meeting of this Association in Carlisle, namely, the late Mr. James Robert Creighton, who then held the office of Mayor, and welcomed the Association and took part in the discussions.

Carlisle Sewage.

The sewage problem has been one which has caused much thought and anxiety for many years past. As far back as 1878, Mr. H. U. McKie, the then city engineer, was requested to report upon the subject. His successor, Mr. Howard-Smith, also prepared a very able report on the same matter; and

shortly after the Author's appointment as city engineer and surveyor of Carlisle, he was requested to give the question of the disposal of the city sewage his earnest attention. At the request of certain Members of the Corporation particulars were obtained as to the feasibility of carrying the sewage down into the Solway and delivering it into tidal waters some 2½ miles below tidal point. The survey and sections were made, and it was found to be practicable without pumping; the cost, however, would have been great, and the Author was of opinion that owing to the very complex currents of the Solway it would be exceedingly difficult to obtain the sanction for such a means of disposal; he therefore turned his attention in 1897 to the bacteriological system of purification of sewage, and after visiting several places where this process was to some extent adopted, it was decided to construct a series of tanks as an experiment, capable of dealing with about a quarter of the dry-weather flow of the sewage (400,000 gallons in twenty-four hours). The land on which the tanks are constructed is the property of the Corporation, and is adjoining the river Eden. It has therefore been necessary to construct the tanks at a somewhat high level. They consist of four tanks, each 120 feet by 45 feet. They are constructed with a 6-inch cement concrete bottom, 15 inches brick walls, built in cement with cement core ¾-inch thickness. The walls are coped with Staffordshire blue bricks on edge. The bottom is laid with a uniform fall of 6 inches in the length of the tank towards the outlet. The tanks are filled to a depth averaging 4 feet with broken stone. The sewage is thoroughly screened before it arrives at the point from which the temporary pump lifts it into the carrier which supplies the tanks. It is then dealt with by an automatic feed apparatus patented and erected by Messrs. Adams and Co., of York and London. This apparatus can be regulated to charge the tanks alternately, then leave them full, and empty them automatically in accordance with the timed syphon, which allows them also a given period for aëration before refilling. The outlet is also provided with an automatic syphon discharge.

According to the following analyses made by Messrs. Dibdin and Thudichum, the sewage of Carlisle is described as being a very weak sewage.

—					Ammonia.		Oxygen Absorbed from Permanganate at 80° F.		Organic Element.		Suspended Matters.		Dissolved Solids.	
	Appearance.	Odour.	Reaction.	Chlorine.	Free.	Albuminoid.	At Once.	In 4 Hours.	Carbon.	Nitrogen.	Total.	Volatile.	Total.	Volatile.
Day flow— 7 a.m. to 6 p.m.	V.W.S.	V.W.S.	N.	3·5	1·360	0·157	0·56	1·81	..	..	13·6	11·4	27·8	8·2
Mid-day flow— 9.30, 10.30, 11·30 a.m.	W.S.	W.S.	N.	4·9	1·950	0·301	0·79	2·37	..	..	14·7	14·5	36·7	9·3
Night flow— 7 p.m to 6 a.m.	V.W.S.	V.W.S.	N.	3·2	0·780	0·105	0·39	1·24	..	..	13·9	3·9	26·7	6·9

V.W.S.—Very weak sewage. W.S.—Weak sewage. N.—Neutral.

The beds have only been in use for a few weeks, and the Members on visiting the works will see for themselves what is the result of these experiments.

Artisans' Dwellings.

In connection with the Bridge Street improvement which has already been mentioned, the Local Government Board required the Corporation, as before stated, to erect dwellings for the labouring classes to provide for those disturbed before the improvement was proceeded with. In July 1897 the Author submitted a design to the committee having the matter in hand, which was approved, and application was authorised to be made to the Local Government Board for the necessary sanction to borrow the money. After considerable correspondence and one or two interviews the sanction was obtained in May 1899. In the following month a contract was let to Mr. Joseph Hindson, Carlisle, for the erection of the buildings amounting to 5333*l.*

The dwellings provided are in two blocks, and are designed on the tenement plan two stories high, and consist of thirty tenements with two rooms, and ten with three rooms. They are entered from a 40-foot street by a 4-foot passage which leads through to the yards at the rear. The entrances to each tenement are quite distinct, those on the upper floor being reached by separate stone staircases. Every tenement has its

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own water-closet and coal place; a wash-house is provided for the use of two dwellings, a back-yard being common to a block of four. The whole of the floors are constructed of cement concrete. Each tenement has water and gas laid on and a sink provided. Ample provision has been made for cupboards and larder; everything has been designed to be plain, strong and substantial.

The kitchen walls are lined to a height of 4 feet 6 inches with cement dado. In the two-roomed tenements the living rooms are 13 feet 6 inches by 12 feet, the bedrooms 12 feet by 12 feet, and in the three-roomed tenements the living rooms are 13 feet 6 inches by 12 feet 6 inches, and the bedrooms 12 feet by 10 feet, and 12 feet 6 inches by 6 feet 6 inches. The height of the rooms on the ground floor is 10 feet, and those on the upper floor 9 feet. The back-yards are finished with 6 inches of cement concrete. The drains have been carefully laid by the Corporation's own workmen. The buildings are erected in local bricks with stone dressing, and the external walls are 14 inches thick.

The streets will be formed by the Corporation with Lazonby flags, kerbs and channels, and paved with Whinstone cubes with asphalt joints on a good gravel bottom.

The whole scheme is expected to cost 6000*l.* exclusive of the land, which was already the property of the Corporation.

Public Markets.

When the Association last met in Carlisle, the Corporation were engaged in the erection of large market buildings. Many persons thought that the buildings were much larger than would ever be necessary for a town of this size. The buildings cost 42,800*l.*, the receipts for the year ending March 25 last amounted to 2557*l.* 10*s.* 6*d.*, the working expenses 1359*l.* 13*s.* 7*d.* Interest on debt 969*l.* 18*s.* 10*d.*, instalment of loan 1420*l.*

In the early part of last year the markets committee felt that it was absolutely necessary to provide for further accommodation in connection with the public markets. They gave the Author instructions to prepare plans for an extension, and in June of last year he submitted a plan extending the market to the street line in West Tower Street, and advised that this portion might well be utilised as the poultry market. The design

was approved, and application made to the Local Government Board for sanction to borrow the necessary money; the sanction was obtained on September 22, and on March 6 last a contract was let to Mr. Thomas Creighton, of Carlisle, for the sum of 2270*l.*

Public Abattoirs.

The public abattoirs in Carlisle were designed by Mr. H. U. McKie and erected in 1886–7. They have proved themselves to be an exceedingly popular institution, and have been of undoubted value to the inhabitants at large owing to the efficient inspection which they enable to be exercised over all the animal food which is killed for consumption in the city. Their popularity is proved by the very large increase which has taken place in the numbers of animals which are annually slaughtered on the premises.

In the year ending March 25, 1889, the total number of animals killed was 18,014 and the revenue 409*l.* 18*s.* 10*d.* In 1899, ten years after, the total number of animals killed was 25,014 and the revenue 561*l.* 4*s.* 8*d.*; and for the past year ending March 25 last, the numbers were 27,479 and the revenue 619*l.* 11*s.* 4*d.*

The health committee decided to provide further accommodation to meet the necessary requirements of the butchers, and in October of last year the Author submitted a plan to the committee showing the proposed extensions, which was approved and a resolution passed to apply to the Local Government Board for sanction to borrow 2102*l.*, the estimated cost. Their sanction has not yet been given, but it is expected that the work will be carried out during the present summer.

Public Bowling Green.

In February 1896 a memorial was presented by the residents in Botchergate ward to the recreation grounds committee asking that the Corporation would lay out a public bowling green for the use of the residents in that portion of the town. After considerable opposition and discussion, a plan and estimate prepared by the Author were approved, and the work let by contract in September 1897, and the ground was opened to the public in July 1898, and has proved to be a very great success.

The total cost of the scheme, exclusive of land and fencing, was 779*l*. It is much appreciated by the public, and the receipts from the use of the ground by players more than cover its working expenses and the necessary repairs.

It has been so successful that the Corporation are now seriously contemplating the construction of another public green at the west side of the town in answer to a memorial signed by upwards of 300 residents in that neighbourhood.

During the past ten years the city has increased very considerably. Appended is a table showing the rateable value, the number of new streets laid out and buildings erected during the eleven years.

Year.	Rateable Value.	New Streets.	New Houses.	Places of Worship.	Schools.	Shops.	Other Buildings.	Total Buildings.
	£							
1889	146,023	3	93	..	..	12	13	118
1890	143,187	1	111	..	..	7	20	138
1891	145,272	7	126	..	..	8	34	168
1892	148,151	17	81	..	1	1	36	119
1893	158,056	13	145	..	..	4	42	191
1894	159,563	7	188	1	..	13	31	233
1895	162,600	16	173	1	6	5	29	214
1896	179,783	2	197	..	1	9	16	223
1897	184,030	7	222	..	..	4	18	244
1898	189,101	16	201	..	..	5	21	227
1899	197,012	6	226	1	..	15	17	259
		95	1763	3	8	83	277	2134

During the same period a large amount of street works have been executed, both public and private, at a cost of 59,800*l*. In addition to these works, the city engineer's department has carried out work in the laying of sewers and drains at a cost of 9500*l*. They have also carried out works chargeable to private persons amounting to 29,600*l*.

The number of men employed in the engineer and surveyor's department averages 180.

The General District rate amounts to 2*s*. 6*d*. in the £. Poor rate is 2*s*. 6*d*. in the £, including 1*s*. 3*d*. for School Board, and 1½*d*. for Public Library and Technical Education.

No City rate has been levied since 1889.

1*d*. rate produces 700*l*.

Area of city	2028½ acres.
Mileage of streets—	
Paved	35 miles.
Macadam	8 „
Total	43 „

Description of Works.

Mr. Dibdin: In accordance with the kind request I have received, I have great pleasure in trying to impart to you some little idea as to the object of these works. Probably most of you know very well the work that has been done in applying the principle of bacterial action to the purification of waste organic matter, whether that waste organic matter be the matter in sewage or other foul liquids. In the present case we have to deal with sewage by a small experimental installation, in which only the first portion of a complete process of bacterial action is applied. I desire particularly to call your attention to the material of which the beds are composed. The expression has often been used that these beds are but filters. Now I ask you to take particular notice of the kind and the size of the materials with which the beds are filled, that is to say, coarse sandstone, roughly speaking of some four, five or six inches in diameter, so that the beds are composed really of a number of cells formed by the juxtaposition of these particles of sandstone, and upon the surface of these particles of sandstone there is a growth of bacteria, and it is to these bacteria that the purification of the sewage is due. Now in the present instance it is not suggested to you that the whole of the sewage of Carlisle is purified perfectly, but the present small installation is only an experimental installation, designed to task the efficacy of the bacterial system in regard to the destruction of the solid matters in the sewage, without attempting to effect that ultimate and final purification which we know can be effected when desired and when the necessary works are erected for that purpose. The beds are filled with the sewage water, which carries with it the major portion of the solid matters of the sewage—a certain portion of the larger matters are screened off at the special screening station, so we are free from rags, and that larger floating débris which is so prevalent in sewage. Any particular bed, of which there are four, being filled with sewage is allowed to rest for a convenient

period of time, about two hours. During that time the solid particles in the sewage settle on the nearest particle of stone by the action of gravity, and as I explained to you these small cavities between the particles of stone form the cells in which the sewage matter is deposited. In these cells the bacteria are rapidly growing and feeding on the organic matters deposited and destroying them. After about two hours the effluent from that bed may be discharged, and on discharging it will be found to have undergone a change to this extent, that practically the whole of the solid matters have been retained in the bed, and about 50 per cent. of the matters in solution have undergone a condition of oxidisation, have been burnt up by the digestive processes of the bacteria. It then remains a question as to how far it is necessary to continue the bacterial action on other beds in order to effect a degree of purification for which the particular beds are designed. If in the case of Carlisle it is required to produce an effluent which is free only from suspended matter, then these first rough beds will be sufficient to meet that requirement. If it is required to produce a higher degree of purification, then it will be necessary to employ a secondary treatment of the sewage. The beds and the treatment will be the same, with one exception, that the particles of sandstone must be broken up to a smaller grain. After undergoing this secondary treatment it will be found that the effluent from these beds may be safely discharged into any running stream, or even any dry watercourse, and it will be found that fish will live very well in the effluent. This installation merely shows a first stage in the preliminary process of disposing of the solid matters of the sewage. Mr. Marks, who has erected these works from general descriptions, supplied by myself, will be able to inform you as to the practical working. There is no cost of chemicals, and the only labour involved is in turning on the necessary valves, where the valves are actuated by manual labour. In this particular installation I draw your attention to the system of automatic valves, by means of which the sewage is adjusted automatically on to the various beds and discharged after the necessary period of rest.

The substance of which the particles are composed does not matter. There is no virtue in the material. It is merely a question of obtaining a surface on which the bacteria can aggregate and do their work.

Mr. Marks: The total working cost of this place is 5*d.* per hour for labour in pumping, and for that favourable result we are largely indebted to the automatic arrangement for filling and emptying the tanks. The effluent we have so far turned out is not so good as we can get. I believe when we come to analyse the effluent it will be found we have removed 50 per cent. of the foul matter. The sewage of Carlisle is a very weak sewage, mostly domestic, with the effluent from some dye works and felt hat works, and the effluent is certainly a great improvement upon what has hitherto been turned into the watercourse by Carlisle.

DISCUSSION.

Mr. J. Price: I should like to propose a vote of thanks to Mr. Marks for the exceedingly interesting paper he has presented to us. The various works we have inspected are most interesting, and no doubt we shall all carry away with us some notes that will be useful in our own practice. I should like to ask what special precautions were taken to make the engine room at the electric light works water-tight. With respect to the chimney, which is stated to be from 3 feet 6 inches at the base to 1 foot 6 inches at the top, I presume this stated thickness of the brickwork at the top of the chimney has reference to the brickwork between the panels, and that at the back of the panels there are only 9 inches of brickwork. Any one who has to build nowadays knows the difficulty of estimating, and the still greater difficulty of carrying out the work at the estimated cost. For that reason I think Mr. Marks is to be congratulated upon the result obtained at the electric light works when the extras reached so small an amount. There is not much to be said about the tramways, which are not complete, but I should like to ask whether there is any reason for using so light a rail as 83 lbs., because the tendency is to have a rail of about 100 lbs. to the yard. In Birmingham a 10-ton steam car runs on eight wheels, whereas in Liverpool an electric car of similar weight runs on four wheels, a difference which has to be taken into account when considering as to the weight of the rails. The name of artisans' dwellings appears to have been carefully selected, for I suppose Mr. Marks does not intend them for use as labourers' dwellings. They are a very nice suitable class of tenement, but I do not see how

labourers will be able to pay the rent which will have to be charged for them. I must say that the Local Government Board, with their restrictive regulations, make it difficult to build dwellings even for artisans, to say nothing of the labouring class. With regard to the sewage, I should like to know the character of what Mr. Dibdin has called a "weak sewage," and it would therefore add to our knowledge if Mr. Marks would kindly add to his paper an analysis of the sewage so described.

Mr. BRODIE: In seconding the vote of thanks I should like to congratulate Mr. Marks upon the very interesting works we have seen, and upon the manner in which they have been carried out by himself and by his predecessor Mr. Howard Smith. I notice in regard to the public markets that the charges for working expenses, interest on and repayment of loan, are considerably in excess of the market receipts. I only want it to be clearly stated that it is so, and not a misprint. I think most of us who have had anything to do with markets will admit that it is a pretty general opinion that while they pay working expenses they do not usually yield sufficient income to cover repayment of loan. Then as to the abattoirs, I should like to know whether the Corporation experienced any difficulty as to the payment of compensation to butchers who have private slaughter houses. We have had the question before us at Whitehaven for years, and the bugbear of compensating the owners of private slaughter houses has prevented anything being done. I gather from the paper that no slaughtering of animals now takes place in private slaughter houses, which is a great advantage, as it enables a very perfect system of supervision to be exercised. Then, I should like to know whether the abattoirs pay their way. I contend that it is not essential that these things should pay their way to justify their being taken up by the public authority, but as we all know, if they are able to show fairly satisfactory financial results we can the more easily persuade our Councils to embark on these necessary sanitary improvements.

Mr. J. P. DALTON: I should like to express my obligation for the assistance Mr. Marks has rendered to me as District Secretary in arranging the meeting, and I think our thanks are due to him for those services. As to the artisans' dwellings, it would be interesting to know the rents to be charged. As to

the sewage works, the bacterial treatment has not been tested here long enough for us to form an opinion as to its success, but in a year or two we may have more information as to the success of the works.

Mr. E. J. SILCOCK: I should like to emphasise the compliments paid to Mr. Marks in having carried out the work at the power station without having exceeded the amount of the tender. I am sure that must be most satisfactory to the City Council, and gratifying to Mr. Marks, and we are glad to see that he has been able to accomplish so splendid a result. With regard to the tramways, I understand that Mr. Marks is not in any way responsible for them, but I should be very glad if he could give us any information as to why the narrow gauge is adopted here. The only reason I can conceive for the decision is that some of the streets are very narrow, but I must point out that the adoption of a narrow gauge involves narrow cars and considerable inconvenience to the passengers. With regard to sewage purification I was very pleased to see the automatic gear in operation. There is no doubt that bacterial systems of sewage purification will be very largely adopted in the near future, and that there will be a very large field for some apparatus of this kind. It is to the manufacturers of specialities for sewage works that we look to perfect these appliances for us. I should like to draw attention to the area of these tanks. Perhaps Mr. Dibdin will say a word or two on the subject afterwards. The area of the tanks is 600 square yards, and the proportion of tanks to sewage is about 1¼ acres per million gallons. That is for one contact only. Now, as I understand it, this sewage is chiefly domestic, and has been described as a weak sewage. Hitherto the pioneers of bacterial treatment have talked of using an acre of contact beds per million gallons for two beds, but here we have got 1¼ acres for one bed, and the effluent, though vastly improved, is, Mr. Dibdin told us, good enough to go on to a fine bed. If we have to provide a fine bed it means an area of 2½ acres per million gallons, and this would probably be sufficient for a strong sewage. That area is pretty much about what other people have arrived at, for we know as much as 3 acres per million gallons have been used in some places. That is probably as little area as we can do with for double contact beds. We should be glad to hear Mr. Dibdin's views on the point, because it has a most im

portant bearing on the question of cost. The artisans' dwellings seem to be of very nice design, and suitable in every way for a good class of tenant, but I am afraid the cost is rather above the standard which is fixed for housing the working classes. I think Mr. Boulnois was the man to formulate the figure that the rent should not be more than 1*s.* per week per room, and at that figure these tenements would be let at 2*s.* and 3*s.* respectively. Mr. Marks rather foreshadowed a rent of 3*s.* 6*d.* and 4*s.* 6*d.* per week. Judging from the character of the house and the amount spent, I think the Corporation could not charge less, and it seems to me that rent is rather in excess of what the poorer class of working people would be able to pay. Otherwise they are very good buildings and first class for the purpose. I take it that the land would not add very much to the cost, but if a similar class of house were put up in certain towns where an area has been cleared, the cost would come out at more than 45*l.* per room.

Mr. R. H. Dorman: Mr. Silcock objects to the 3 foot 6 inch gauge which has been adopted on the tramways in Carlisle, but I may say in Ireland we have a large number of light railways of that gauge, and we find it is quite sufficient. In the case of carrying heavy cattle, there may be occasionally some little trouble, but that is the only difficulty. With respect to the widening of the bridge over the river, I should like to ask why, if all the approaches to the bridge are within the city, the County Council should pay 3000*l.* to the City Council for taking over the present and future liabilities of the bridge. With regard to the bacteria beds, while they are working in some towns with the closed or septic tanks, here you are working with open tanks, and there is very little or any difference in the results. We are working at Portadown with a closed tank, which is opened once or twice a year to clean out the small amount of matter which accumulates in it, after which the tank is often left open for a fortnight or so, during which time we see apparently the same processes going on as in the closed tank.

The President: I wish to take the opportunity of thanking Mr. Marks for the very valuable paper which he has read. I hope Mr. Marks will tell us what rent he proposes to charge for the artisans' dwellings; but I fear if the scheme is to prove remunerative the rents will be a little too high for the class of tenant intended.

Mr. Marks: I am very much obliged to you for the very kind way in which you have spoken of my efforts to-day, because I can assure you that, like most young people making their "maiden effort," this meeting has been a matter of great concern to me. So far as the discussion on my paper is concerned, I will endeavour to deal with the questions in the order in which they were put. Mr. Price has asked how the buildings at the electric power station have been made water-tight. Well, practically they are tanks. The concrete walls were floated and made complete tanks. Then the brickwork had a cavity filled in with hygienic rock asphalt. Though we have had the water many feet above the trenches in the boiler-house, we have experienced no difficulty whatever, and had no water in the trenches. Therefore, I take it the asphalt has been a success. Mr. Price's question as to the thickness of the brickwork at the top of the chimney gives me great pleasure, because it shows that the City Engineer of Birmingham considers 9 inches sufficient, and with the panels 14 inches. I designed it in that way, but the Local Government Board Inspector said it was not sufficient, and only passed it on condition that we made it 18 inches thick. I think the tram rails will prove heavy and strong enough for the small cars we are going to have in Carlisle. The cars are the same as those now running in Dover. In answer to Mr. Silcock, I may say the narrowness of the gauge is due to the narrowness of the streets. The Corporation objected to tramways altogether until they visited Dover and saw it was practicable to run tramcars in streets which are even narrower than those of Carlisle. The dwellings are intended for labourers, and the Corporation will probably let them at 3*s.* 6*d.* a week. The majority of the labouring class can afford to pay the rent, and do pay it at present, and in some cases for "kennels" and not for dwellings. As to the 1*s.* a room fable, that was in hand at Liverpool before Mr. Boulnois' time. I was there in Mr. Dunscombe's time, and I know we wasted a good deal of time and paper on it, but it was unsolved and will remain unsolved. The sewage is a very weak sewage, and as the water into which the effluent is discharged is not used in any way as drinking water, the effluent we are now producing is not likely to do harm to anybody. Mr. Brodie has asked as to whether compensation was paid to the butchers. At the time the abattoirs were built the whole of the slaughter-houses were licensed by the Corpo-

ration to the butchers under annual licences, and they had no claim to compensation. The butchers are now so pleased with the abattoirs that animals are brought from outside districts to be killed. The number of animals killed has increased by 2500 during the past year. The abattoirs pay the working expenses and interest on capital, but not repayment of loan. With respect to the artisans' dwellings, taking the period for repayment of loan at 30 years, I calculate that we shall lose during that period, but on the repayment of the loan, the City will come into possession of an unencumbered property which has cost 6000*l*. With regard to the automatic arrangement for filling and emptying the sewage tank, the syphons are working extremely well, and they do not sleep during the night. If we had a man doing the night shift and there was no overlooker coming on until 7 o'clock in the morning, it would be an easy thing to run the sewage down the bye-pass if there was one. The automatic arrangement does not do that sort of thing. Mr. Dorman has answered for me the question as to the narrow gauge of the tramway by pointing out that the same gauge works extremely well in Ireland. Mr. Dorman asked whether the bridge which it is proposed to widen belonged to the county. All the bridges over rivers and streams in the city are the property of the County Council, and the railway bridges are the property of the railway companies. In this case the County Council have agreed to pay the city 3000*l*., and we make the improvement and take over the liability of the bridge.

Mr. Dorman: Why do they pay you the 3000*l*.?

Mr. Marks: Because we say they have a liability to widen it, as it is at present too narrow for the traffic.

CARLISLE ELECTRIC LIGHTING.

By CHARLES D. BURNET, A.I.E.E.,
City Electrical Engineer.

A Provisional Order was granted in June 1895, and in 1897 the Corporation appointed Professor Alexander B. W. Kennedy, F.R.S., LL.D., M. Inst. C.E., to be their Consulting Engineer.

A report was submitted by him on the 27th of March, 1897, and being considered satisfactory by the Council, Professor Kennedy was instructed to prepare the necessary drawings and specifications for the first installation.

Site.

Some little difficulty was experienced in the selection of a suitable site. The present one in James Street was finally decided upon, however, on account of the great facilities for coaling and condensing offered by the proximity of the railway and the river respectively—advantages not possessed by either of the other sites.

System.

Professor Kennedy recommended a low-tension three-wire direct-current system of supply.

Buildings.

The buildings were erected from the designs and under the superintendence of Mr. Henry C. Marks, Assoc. M. Inst. C.E., the City Surveyor. These comprise the offices and store rooms, which are situated over the battery room and workshop, facing James Street. Behind this is the engine room which is 65 ft. 6 in. long by 35 ft. 6 in. wide, lined with white glazed brick. Behind this again is the stokehole, which is 62 ft. 3 in. by 74 ft. 9 in.

The chimney is 160 feet high, circular, 7 feet in diameter at the top, and is lined for a height of 100 feet with firebrick,

an air space having been left between the lining and outer structure.

Foundations.

The foundations are laid upon the gravel.

Plant.

The original installation consisted of, in the stokehole, three Lancashire boilers, 28 feet long by 8 feet in diameter, made by the Oldham Boiler Works Company, Limited, Oldham, working at 160 lbs. pressure. Each boiler is capable of evaporating 8000 lbs. of water per hour. The boilers are fitted with the patent mechanical "Auto Stoker" made by the Union Ironworks Company, Ashton-under-Lyne.

Each boiler is provided with the following fittings:—one spring safety valve, one low-water alarm, one lever safety valve, two shut-down feed-check valves, one blow-off cock, one scum cock, one steam pressure gauge, one fusible plug, two gauge glasses.

Pump Room.

Pumps.—The first set of pumps comprised two horizontal, compound, duplex Worthington pumps, each capable of delivering 1400 gallons of water per hour against 160 lbs. pressure.

The feed water is taken from the town main. The *feed tank* is situated over the pumps, and is capable of storing 3300 gallons of water.

Economiser.

The water, after passing through a Kennedy water meter, is pumped through a Green's economiser of 192 tubes, and from thence through either of the two bus pipes which lie in a chase in front of the boilers to the feed-check valves on the boiler fronts. An alternative method is to cut out the economiser altogether and feed the boilers direct by means of the bus pipes before-mentioned, which are in duplicate.

Steam Main.

The boilers deliver steam into an 8-inch ring main. The straight lengths are of lap-welded steel $\frac{1}{4}$ inch thick, with flanges $1\frac{1}{8}$ inches thick screwed and brazed on. The bends are of solid drawn copper with steel flanges brazed on. T pieces

are of cast iron. The valves are so arranged that any section of the ring can be cut out without interfering with the running of any of the engines.

Drain Pipes and Separators.

In the boiler house there are two main separators which are drained by hand into the pipe leading into the sump or river. Into this pipe are also led other drains from the T pieces, valves, pumps, etc.

Auxiliary Machinery.

There are two small engines, one in the pump room for driving the auto-stokers, and another on the economiser for driving the scrapers.

Extensions.

In view of the Tramway Company's demand for electric energy, and in order to cope with the rapidly increasing demand for electricity for lighting purposes, extensions had to be considered before the original installation was thoroughly under way.

The extensions in the boiler house consist of two more boilers similar to those already installed, the settings for which are ready to receive the boilers.

The economiser has been doubled, and another Worthington pump similar to those already in use has been supplied.

Engine Room.

The first installation consisted of four Willans engines direct coupled to Siemens dynamos. The two small sets Nos. 1 and 2 are used as balancers and run at 460 R.P.M. Each engine is 100 I.H.P. and drives two 30·2 kw. shunt-wound dynamos, one at each end. The E.M.F. of each dynamo can be varied from 230 to 260 volts with a variation of speed not exceeding 5 per cent. from the normal.

The two larger sets Nos. 3 and 4 consist of engines of 200 I.H.P., running at 350 R.P.M., coupled to shunt-wound Siemens dynamos having an output of 125 kw. at any E.M.F. from 460 to 520 volts. These machines supply the outers of the three-wire system. Dynamos Nos. 3 and 4 have also a series winding to be used when on a traction load.

The following table shows the water consumption and efficiency of these sets on test.

Particulars of Load.	100 I.H.P. Sets.			200 I.H.P. Sets.		
	Lbs. of Water.		Efficiency.	Lbs. of Water.		Efficiency.
	I.H.P.	E.H.P.		I.H.P.	E.H.P.	
Full load . . .	17·55	22·46	78·35	16·5	20·32	81·25
Three-quarter load . .	18·6	25·23	73·7	17·22	22·27	78·35
Half load . . .	18·91	28·68	66·31	18·02	25·16	71·1
Quarter load . . .	19·77	38·22	51·73	20·08	34·4	58·37

Condensing plant.—Each engine is fitted with a "Ledward" ejector condenser designed to maintain a vacuum equivalent to 26 inches of mercury in the exhaust pipes. To supply these, water is taken from a sump in the river, a distance of 160 feet, by means of a 7-inch Bon-Accord centrifugal pump driven by a 25 B.H.P. shunt-wound Siemens motor running at 750–900 R.P.M., and is delivered into a large tank situated over the economiser on the boiler house roof at the rate of 45,000 gals. per hour. The height of the water in this tank is 36 feet above the engine room floor.

The condenser tank is capable of containing 25,000 gallons of water.

Atmospheric exhaust.—By means of a system of automatic valves it is not possible for the condensing water to get back into the engines. Should one of the condensers get choked from any cause a valve closes between it and the engine, and another opens to the atmospheric exhaust. This pipe lies in a chase by the side of the concrete engine block, and terminates in a vertical pipe 12 inches in diameter, the top of which is 44 feet above the engine room floor level.

The crane.—Overhead there is a 12-ton travelling crane, made by Messrs. Carrick and Ritchie of Edinburgh, spanning the engine room and manipulated by ropes from the engine room floor.

The booster was supplied by the Electric Construction Company, Limited, Wolverhampton. It consists of two 4·2 kw. generators on either side of a motor mounted on the same

base plate. The motor is shunt-wound and capable of running at any speed from 500 R.P.M. to 1050 R.P.M., at any voltage from 460 to 520 volts. The normal output of each generator is 0 to 60 amperes, at from 10 to 70 volts, at whatever voltage or speed (within the above limits) the motor may be working. The fields of the generators are separately excited with 230 volts taken from the bus bars. The armatures can, without detriment, be doubly loaded for half an hour. The booster is manipulated from the battery panels on the switchboard, and is used for charging and discharging the batteries.

The switchboard was supplied by the Electric Construction Company to Professor Kennedy's designs, and consists of black enamelled slates mounted on a metal framework.

On the right-hand side are two battery panels on which the following instruments and switches are mounted:—battery emergency switches, battery regulating switches, booster reversing switches, voltmeters and ammeters, booster shunt switches, and motor starting switch. In addition to these there is a plugging arrangement by which the booster can be connected, so as to (*a*) charge or discharge the batteries, (*b*) milk up any particular cells in the batteries, or (*c*) be connected up for meter testing.

On the left of these are two panels for the balancing dynamos with ammeters, double pole automatic switches fitted with carbon sparking contacts, change over plug bars, and main plugging switches. At the top of each panel are feeder switches and feeder ammeters.

In the centre is the lighting voltmeter panel on which are mounted the feeder, dynamo and bus bar voltmeters and switches, also the middle wire and earth ammeter.

At the extreme left on the original switchboard are the main dynamo panels for Nos. 3 and 4 sets, fitted with double pole automatic switches with carbon sparking contacts of the Electric Construction Company's well known pattern. The dynamo, ammeter and main plugging bars are above these, and at the top of the panels are the feeder ammeters and switches.

The switchboard has been so arranged that any dynamo or feeder can be plugged direct on to either of the two pairs of bus bars. By this means two distinct pressures can be maintained on the network if necessary.

On the hand-rail in front of the switchboard the shunt regulating switches for all the dynamos and booster have been placed.

The station meters are fixed on the wall in front of the raised platform and are of the "Aron" type.

All the machines are fused on both poles, and the fuses are fixed on the wall at the back of the switchboard.

The extensions for lighting and traction purposes in the engine room consist of two 400 I.H.P. Willans engines, coupled direct to multipolar dynamos by Messrs. D. Bruce Peebles and Co., Edinburgh. These sets are to run at 300 R.P.M., the generators to have an output of 250 kw. at any voltage from 470 to 530 volts.

They will be run compound on the traction load, and as shunt machines on the lighting load.

Switchboard.—Two lighting panels for Nos. 5 and 6 sets are being provided by the Electric Construction Company, also traction panels for Nos. 3, 4, 5 and 6 sets. These are placed vertically under their respective lighting panels and occupy one-half of the total height of the switchboard.

A traction voltmeter panel has also been added in the corresponding space left below the lighting voltmeter panel.

The balancing dynamo panels have also been altered to enable the two small sets to be used on a traction load, if necessary.

Traction feeder board.—This is being supplied by the Electric Construction Company, and is being placed at right angles to the main switchboard.

On the left of this is the Board of Trade testing panel. Beneath are the Corporation and Tramway Company's meters, to record the total output for traction.

To the right, provision has been made for three traction feeders, with three automatic switches having a quick and long break, with carbon contacts to take the spark, and corresponding ammeters.

Batteries.

The battery room adjoins the engine room, and is 44 ft. 6 in. long by 19 ft. wide. It is situated below the offices. It contains 250 15-plate chloride cells, in glass boxes arranged in

two tiers on four wooden supports running lengthways in the battery room.

The regulating switches are on the battery panels on the switchboard in the engine room. By means of these the batteries need never be taken off circuit, and the booster can be put in and the batteries charged or discharged without causing any fluctuation in the lights. Interlocked with the regulating switches are the booster reversing switches, by meaus of which the booster is put in circuit for the purpose, as previously stated, of charging or helping to discharge the batteries. This arrangement was designed by Professor Kennedy, and works most satisfactorily.

Mains.

The distributors are by Callender's Cable and Construction Company, Limited, Erith, and consist of triple concentric conductors, ·12, ·06, ·12 square inch jute-insulated, lead-sheathed, steel-taped cables.

The feeders are ·25, ·25 square inch section, and are similarly insulated and protected.

The pilot wires are three-core $\frac{7}{22}$ cables.

The arc light cables are ·022 square inch section, concentric, all insulated and protected as before mentioned.

Method of laying.—The whole of the above cables are laid direct in the ground, at a distance of 12 inches from the surface, except where they cross under the streets. Where this is the case they are laid 2 feet below the surface.

Extensions of the network are now being laid in the shape of three single cables, laid on Callender's patent solid system, in cast-iron troughs.

Public Lighting.

Originally 25 10-ampere Crompton arc lamps were erected in the main streets of the city. These are now being increased by the addition of five more lamps of the same pattern, and are run ten in series across 460 volts.

Two Stewart enclosed lamps have been placed outside the Town Hall, and two Davy enclosed lamps outside the Electric Lighting Station.

They take 5 amperes, and are connected two in series across 230 volts.

General.

The Author superintended the erection of the machinery, etc., for Professor Kennedy, was appointed City Electrical Engineer by the Council, and commenced his duties in January 1899.

The Works were opened by the Mayoress, Mrs. George White, on the 11th of May, 1899.

Up to the 25th of March, 1900, 167,032 units were generated.

10,600 8-c.p. lamps, representing 128 consumers, had been connected up.

The prices charged for electricity are as follows:—

Lighting.

Not exceeding a consumption of 1000 units per annum, 5*d.* per B.T. unit; 1000 and not exceeding 3000, 4¾*d.* per B.T. unit; exceeding 3000, 4½*d.* per B.T. unit.

Motive Power.

Not exceeding 50,000 units per annum, 2*d.* per B.T. unit; exceeding 50,000 units per annum, such terms as may be agreed upon by the Corporation and the consumers.

The price charged to the Tramway Company is as follows:— 50,000 B.T. units, 2*d.* per unit; for the next 100,000 B.T. units, 1¾*d.* per unit; and above 150,000 B.T. units, 1½*d.* per unit.

The Tramway Company guarantee to pay the Corporation for a minimum number of 100,000 units per annum.

The Corporation offices and Tullie House pay for current at the rate of 2*d.* per Board of Trade unit.

Ten ampere street arc lamps are paid for at the rate of 23*l.* per lamp per annum.

The gas-works are owned by the Corporation. The price of gas is 2*s.* 3*d.* per 1000 cubic feet.

DISCUSSION.

Mr. J. Lobley: Mr. Burnet is entitled to our thanks for the trouble he has taken in preparing the paper. There are one or two points upon which information might be of interest to the meeting. Mr. Burnet says the boilers are fitted with mechanical stokers. I should like to ask if they have been found of good service. We spent considerable sums in automatic stokers, but they have nearly all been discarded, because their upkeep was great and their ability doubtful, and we have returned to hand firing. I understand that a capital outlay of 30,000*l.* has been incurred on the installation here. It would be useful to know how this is divided into cost of land, buildings, generating machinery and mains, and also the periods for which the loans have been granted. It makes a very serious burden upon the ratepayers if the periods of repayment are very short. The Local Government Board have given my Corporation the very short periods varying from ten to twenty-five years for the repayment of loans for electric lighting. It would be useful to know the length of distributing mains. A great controversy is now going on with respect to the municipalisation of different undertakings. I am one of those who have always advocated the municipalisation of all works which entailed the cutting up of our streets. In the town I represent we are being subjected to a good deal of criticism in the press, because we had an adverse balance on our electric light account, after paying interest and sinking fund charges during the past year. When we started the works six years ago we anticipated that we should not be able to pay all charges out of revenue for some years. We did, however, pay our way at the outset; and the deficits have come later. The fact is, we were too successful at the start. We had so much demand for the light, though for a very short time daily, that the committee were obliged to extend their buildings and machinery, and were also persuaded to extend their mains widely and to reduce the price of current considerably. Now with an unexpected but serious rise in the price of coal we have a deficit in our accounts. Those who have criticised us do not appear to be aware that most installations have been carried on at a loss for the first few years. But most of those towns have subsequently made a profit and

returned the money to the pockets of the ratepayers. But while in our case there is a loss on last year's working, the sinking fund has been growing, until it is now about 6000*l.*—a sum very much larger than the total deficits. I cannot conceive a greater blow to municipal enterprise than the proposition that every undertaking is to make a profit of at least 6 or 7 per cent. each and every year before it can be considered a success. It is absurd to think that every undertaking, municipal or otherwise, can earn 7 per cent. from the beginning. It will be interesting to see how this installation goes on, and whether, at the prices charged, Carlisle will make sufficient to pay the working expenses and interest and repayment of loans. For the public lighting the 10-ampere arc lamps are to be charged for at the rate of only 23*l.* per annum. I should like to know whether these lamps are to be turned off at or before midnight, or kept alight all night. Then as to the charges for private lighting, I hope Carlisle will not regret reducing the maximum charge to 5*d.* per unit, because unless there is a very large consumption it is difficult to see how that price will meet the charges which will ultimately fall due for interest and sinking fund. My experience is that it is better to keep up the first price and to make a substantial reduction on the second price, after one hour's use of the light. This is the experience of many towns. For instance, Blackpool is charging 8*d.* and 2*d.* per unit, and Brighton 7*d.* and 1*d.* per unit. It would have been better had we kept to our first price in Hanley, and made the reduction on the second price. I have much pleasure in moving a vote of thanks to Mr. Burnet for his valuable paper.

Mr. Brodie: It has been a great pleasure to us to see the electric light works, which have been admirably designed. I should like to hear from Mr. Burnet as to the working of the automatic stokers, because my electric lighting committee were on the point of putting in these automatic stokers, but after what Mr. Lobley has said I shall be chary in doing so. Then I should like to know if they have experienced any difficulty from fall of pressure at the outside points of the area of supply. We have had great trouble at Whitehaven in this respect, but then we were very early in the field with our electric light installation, when no practical experience on such points had been obtained.

The Members attending the Meeting were entertained to luncheon by Alderman B. Scott at the County Hotel, and paid visits to Tullie House, one of the most interesting architectural and archæological treasures of Old Carlisle, now devoted to the public service as a free library and museum; the Sewage Works near the River Eden, where a portion of the sewage is treated on the bacteria system; the markets and artisans' dwellings in course of erection. In the evening the Mayor, Mr. W. Ling, entertained the Members to dinner at the County Hotel.

REPLY TO DISCUSSION.

Mr. BURNET (*communicated*).

In reply to Mr. LOBLEY: The auto-stokers supplied with our boilers were not provided with conveyors, it being considered unnecessary at the time, and, as a matter of convenience and for the purpose of preventing smoke, I am using the movable bars only now. By means of these I find that I can use cheap fuel to the best advantage and get practically no smoke.

Similar stokers are being supplied for the two extension boilers.

Up to the 25th of March we paid 7*s.* 6*d.* per ton for coal, by contract, subsequently this price has been doubled for similar coal.

The repayment of loans is spread over a period of twenty-five years.

Length of distributor 4·35 miles.

Price of Current.—About 47 per cent. of the current sold has been taken by the Corporation for lighting public offices, Tullie House, and the street arc lamps, and the price of 2*d.* per unit does not cover working expenses, the total cost being 3·28*d.* B.T.U.

All the street arc lamps are alight from dusk to dawn. There is a proposal to use incandescent lamps on the posts after 11.30 p.m. when the arcs themselves will be switched off.

In reply to Mr. BRODIE: In order to maintain a pressure of 230 volts across the consumers' terminals at times of heaviest load a pressure of 475 volts is maintained on the bus bars.

ANNUAL MEETING IN LONDON.

July 19 and 20, 1900.

THE PRESIDENT'S ADDRESS.

By CHAS. H. LOWE, M. Inst. C.E.

Gentlemen,—

It is with no little gratitude and pride that I rise to return my sincere thanks to the Council and general body of Members of this Association for the great honour you have conferred on me by your election of me as your President for the ensuing year. When I recall the names of the distinguished men who have been my predecessors in this chair, I cannot but feel how small, comparatively, are my claims to such an honour—an honour, gentlemen, which may be justly considered as the highest of the very few distinctions to be gained in our branch of the public service, and which may be regarded as the blue-ribbon of our profession.

I feel that the only claim that can possibly have had any weight with you in this selection is, if I may so term it, the faithful and conscientious discharge for many years of my duties in my position in the public service.

I enter my year of office, gentlemen, with a great amount of diffidence as to my qualification to give that satisfaction to the Association I should so much desire. At the same time, my anxiety to do my utmost in the best interests of the Association I know will meet with your cordial support and assistance, and I can only hope that some allowance will be made for my many shortcomings whilst endeavouring to fulfil so important a post.

I am sure that I am only giving expression to the sentiments of other Metropolitan Members in acknowledging and thanking the Association for the great privilege granted us in

the year 1887, when the door was thrown open for our admission, and we were first made eligible as Members of the Association. The fusion, I feel sure, has proved beneficial in extending our ideas in the many branches of the profession, and, at the same time, has resulted in unity of action for the general good.

It must often have struck Members of the Association, who from year to year have listened like myself to the address of the President, how difficult it must be, as each year comes round, for him to frame anything new or even interesting for the Members—to avoid travelling over well-beaten tracks, or being guilty of plagiarism; and as I can lay no claim to be a contributor to any great extent to the shrine of fame by way of municipal sewage schemes, water, gas supply works or the like, but can only give a sketch of my experience in the various departments connected with an important and growing district, I must claim your indulgence.

The most important change to which Metropolitan Engineers are now looking forward is that of the substitution in November next of the new Local Government Act, 1899, for that of the Metropolis Local Management Act, 1855.

It is difficult to gauge how far the new arrangements may affect the officials in practice; whether the change will be to a great extent in name only, or will really extend the powers of the ruling authority; whether it will succeed in waking up the general public to the proper appreciation of their duties, so that all may take a fair share of administration, and cause them to show greater interest in public works than has been shown in the past. There is room, no doubt, for great improvement in the direction of uniformity of practice in our several districts, so that civil life and spirit may be enhanced and enlarged, and that all may work for one common object, the public good.

The new Corporations, at the outset of their career, will have many important matters to deal with, as for instance, the application of the light railway system to London and its suburbs, the contemplated general extension, by the London County Council, of the tramways, the provision of artisans' dwellings, whilst improvement in motor traction, electrical trams, etc., may fill an important place.

Now that the titles of vestries, district boards, etc., are about to disappear from administrative life in the Metropolis, I think it is a good opportunity for me to say something as to the

extensive work which has been carried out under my personal experience by one of these much abused bodies during the past thirty years, and in defence of administrators who have given up their time and talents most cheerfully to the service of the public without fee or reward, and solely in pursuit of local self-government—a phase of our public life which arouses feelings of astonishment in other countries.

At the time of the passing of the Local Management Act, 1855 (Sir Benjamin Hall's), London was in a chaotic state—governed by paving boards, private trusts, Greek Street commissions and the like—and the object of this Act (1855) was to remedy the defects of this divided authority, and infuse new life into local self-government.

The Metropolitan Board of Works, when established, consisted of selected men from each vestry, who with all their faults did excellent work for the public benefit prior to their being superseded by the London County Council in the year 1888.

The 1855 Act has, on the whole, worked well, and doubtless its administration would have been much more efficient had the public in general taken more interest in its working; this lack, in my opinion, was to a great extent the cause of its partial failure, rather than any inherent fault. In fact, the want of appreciation on the part of the public for good work honestly done by those they chose to send as their representatives and to protect their interests, ultimately gave rise to apathy and sometimes indifference on their part.

It is anticipated by many that the new corporate bodies about to be created will possess far greater importance and dignity by reason of the class of men who will be induced to come forward as aldermen and councillors; but it may be questioned if they will prove more useful, for at present, with few exceptions, the local authorities are composed of hard-working representatives, many with technical knowledge in several of the industrial branches connected with town work, besides a considerable number of professional men who freely give the benefit of their information on legal and other subjects.

I propose now to mention briefly some of the work carried out, and a few of the comparative items of expenditure, of the Hampstead Vestry during their term of office since 1855, this being a district typical of many in this Metropolis.

The area of the parish of Hampstead is 2248 square acres, the length of roads 55 miles, length of footpaths 120 miles.

In 1855 the population was 14,000, and is now estimated at 88,000.

In 1855 the number of houses was about 1900; at the present time the number is 12,250.

The rateable value of the parish in 1855 was 7768*l.*; it is now 851,413*l.*

The length of private roads and footways made up by the vestry at the expense of the owners has been 49 miles, representing an outlay of 190,000*l.*

The main drainage of the town of Hampstead and adjoining localities situate in the district has been carried out at an expense of about 70,000*l.*

The various public improvements, widening streets, etc., represent an expenditure of about 130,000*l.*, towards which the late Metropolitan Board of Works or the London County Council have contributed.

I may also mention that the cost of maintenance of highways in 1859 was 6298*l.*, whilst in the present year it is estimated at 31,500*l.*; the removal of house dust since 1859 has increased from 300*l.* to 8500*l.* per annum; saying nothing as to the additions made in the precepts of the London School Board and the London County Council, which in the case of the former has risen from 600*l.* paid in 1873 to 52,000*l.* paid last year.

I should like now to dwell as briefly as possible on the various departments supervised by the engineer and the surveyor, and on the responsibilities and anxieties which he has to encounter in the ordinary paths of his duty.

I will commence with that most important sanitary department, the sewers, since the questions as to sewer ventilation and house drainage are ever with us.

In an almost purely residential district like my own, it is astonishing to note the amount of sentiment, and at times almost hysterical anxiety, which so largely affects the consideration of these questions, rendering it often most difficult to arrive at the true facts of the case.

By the adoption of additional flushing power, with open and free ventilation of the sewers, complaints have been reduced to a minimum. Those now received are for the most part attributable to the modern system of house drainage

whereby solid matter is often held long in suspension, retarding the proper flow in the drain, and by the insertion of apparatus for cutting off of reputed sewer air; in many cases the complaint has been found to be of a sentimental character rather than of a practical nature.

This branch of our duties will always command the most serious consideration of this Association, so closely does it bear upon the subject of the public health.

The improvement effected in all matters connected with sewers and house drains cannot but be remarked, and, as the death rate goes to prove, the cordial co-operation of the medical officers of health in the carrying out of our duties has been fraught with the greatest good to London.

Combined drainage is still a vexed question, and further trouble may be experienced before we succeed in finding any remedy for the present state of things, unless we receive the aid of increased Parliamentary powers.

The maintenance and repair of highways is the next subject of great importance, conducing as it does so largely to the well-being and comfort of a district. That there is a growing interest in the condition of our roads cannot be denied; whether it be the outcome of the wheelman's agitation for a smooth surface or not, suffice it to say, it exists, with the result that the standard by which the condition of roads is judged has been very much raised. We have the Roads Improvement Association issuing numerous pamphlets on the subject of road-making, and although these are intended primarily for the guidance of the country roadsmen, they reach the hands of the public, and are frequently quoted for the benefit of the local authority in the form of criticism or complaint.

The extensive work involved in the "upkeep" of the public roads increases year by year, and consequently the cost, attributable, as before implied, to the superior condition now demanded, to the advance of the prices of labour and materials, and above all to the enormous increase in all classes of traffic.

The omnibus traffic, more perhaps than that of any other description, has shown the greatest development, no doubt brought about by the reduction in fares; for whereas in 1859 the average fare per passenger was rather more than 3½*d.* it is now less than 1½*d.*

By the old system of macadamising we are at once reminded

of the large gangs of pickers employed, the long and continuous sweeping in, the use of "fence horses" to drive the traffic on the rough stone surface, the watering in and constant attention to get the new stones shut in before all their angular and keyed properties were worn away; this process lasting for weeks and weeks until the whole was consolidated and run in by the vehicular traffic. Now all this is changed, the steam-roller follows immediately upon the pickers or the scarifier, and the whole is completed in a few hours.

I am almost afraid to touch upon so debatable a question as the size of the stone to be used for macadamising purposes, and I hope at some future time this matter will be fully discussed by this Association. The amateur road-makers who write to the press are exceedingly fond of quoting Macadam and his system, entirely ignoring the change in the circumstances as regards the great increase of narrow-wheeled and heavy vehicles, the use of steam road rollers, etc., and the unsuitability of the use of very small stones for all classes of roads as advocated by some who fail to differentiate between the several classes of road traffic.

The question of the use of hard or soft woods for paving purposes is still with us and to a great extent very undecided; no doubt we shall hear more on this very important question at a later date when Jarrah and Jarrahdale have had a fair trial and the several promises made on their behalf when first introduced have been fulfilled; we have also many other kinds of wood in the market, said to be suitable for paving purposes, amongst them Red Gum, White Oak, Ingle wood from Burmah, all of which may claim our attention in the future.

Road watering, the next subject under notice, appears at first glance to be of little importance, but it is often the subject of great anxiety to the surveyor. He must distribute the proper quantity and no more; the shopkeepers and provision-merchants want plenty; the cyclist wants little, would rather have none than too much; the housekeeper just enough to keep the dust out; and the pedestrian water without slop.

A late influential member of my board some years ago felt so keenly the impossibility of pleasing everyone that he moved "that no allowance be made for the item in the surveyor's report for road watering as it was a pure luxury"; but his mind was quickly disabused of this idea, for road watering is quite

as much required for the preservation of the highways as for the comfort of those who use them.

The department of scavenging and removal of street refuse, etc., forms a large item of expenditure with every well regulated district, and should be carried out efficiently, not only for the health and comfort of the inhabitants, but also for the preservation of the roads themselves.

Districts consisting largely of asphalt or paved roads have a great advantage in this respect, as the washing and cleansing becomes an easy matter, while macadamised surfaces have to be very differently treated and in very wet seasons must be carefully dealt with, otherwise the surface of the roads would disappear altogether.

Whilst upon the subject of street cleansing I may refer in passing to the vexed one of snow clearing and removal, although at this time of the year it may appear somewhat out of place to speak of snowfalls.

I am afraid the public in general have no idea of the magnitude of this work, nor have they the slightest conception of the difficulties which local authorities have to encounter in endeavouring, I fear unsuccessfully, to meet the public demands.

We are now fully aware, by the experience of recent years, of the impossibility of giving satisfaction in extensive districts like mine with regard to the cleansing of footways, the burden of which was thrown upon the local bodies by the Public Health Act, 1891. Most engineers and surveyors at that time practically acquainted with the work warned their respective boards as to the difficulties which were likely to arise.

The issue between the public and local authorities is a simple one, viz. whether the former are prepared in a district such as Hampstead, to meet an additional call for this purpose of 5*d.* or 6*d.* in the pound on the rates (presuming always that sufficient labour, cart hire, and convenient shoots for snow can at once be obtained), or put up with a little personal inconvenience, generally of short duration.

This subject was considered of so much importance that repeated conferences have been held with a view of obtaining some alteration in the law, and in March last a meeting was held at the Paddington Vestry Hall, consisting of delegates from the several local authorities in the Metropolis.

On that occasion a delegate from an East End parish spoke

strongly in support of the new arrangements and saw no difficulty, but in a self-confident manner told us how well everything had been done by his board. However, when one came to look into the matter it was ascertained that this particular district covered the small area of 239 acres, comprised only 15¼ miles of paved roads, therefore by no means a typical case, many of the Metropolitan districts covering an area of from 2000 to 3000 acres and with a length of road of from 90 to 100 miles, chiefly macadamised.

The removal of house dust and its disposal, perhaps as much as any other department, gives the municipal engineer no inconsiderable amount of work.

The old dust-heap, with its accompaniment of tot and bottle pickers, cinder sifters, etc., has entirely disappeared from the neighbourhood of our districts, together with the familiar adjacent brickfield, greatly to the public benefit.

In place of all this, the dust-destructor has arisen to deal with the refuse. This it does effectually, so far as any nuisance is concerned, leaving a residue of calcined material fit for clinker paving or foundation core, to the extent of about 17 per cent., and about 8 per cent. of fine ash suitable for various purposes in the building trade.

When my vestry contemplated, in the year 1886, establishing a dust-destructor yard, great was the outcry against placing it near residential property, and a site was found far removed from all dwellings; but since that time a great change has come over the intelligence of the public. Dust-destructors are no longer considered to be a nuisance, but in some cases have been placed in the immediate vicinity of populous neighbourhoods. In my own case, dwelling-houses have been erected immediately facing the Hampstead destructor at Willesden, and now destructors are erected, as I before mentioned, in the midst of districts they are intended to serve and the waste heat utilised for electric lighting purposes. Thus does one district gather useful economical knowledge from the early action of others, and, to a certain extent, at their expense, even tempting one under some circumstances to advocate a masterly policy of inactivity.

The adoption of the present system of house-to-house call, a weekly collection and its disposal, has, of course, involved a considerable extra outlay. As stated, in the year 1859 our charge for dust removal was 300*l*., whilst in 1900 no less a sum

is estimated to be required than 8500*l*. This, to some extent, is accounted for by the increased number of houses, but in a larger degree is owing to the high state of efficiency required by the public in the work of this department, and because under the old system the duty was never properly performed.

Considerable trouble has been experienced of late years with the clearing of dust-bins or dust-skips from the better class houses in my district, through the accumulation therein of all kitchen refuse, fish, offal, fat, etc., which quickly decompose and become offensive. Here one misses the unsavoury swill-carts of our boyhood days, which were to be seen at early morn in most West End districts, collecting such refuse for the hog-tub; and, however one may rejoice at the disappearance from London streets of the swill-cart, the dust-bin is hardly the proper receptacle for this refuse—an extra sealed or air-tight covered skip should be provided for this purpose.

A few remarks may not be considered out of place with regard to open spaces and tree planting.

In recent years this department has claimed an important place in connection with local management, and there are very few districts, if any, which are not provided with open spaces. Hampstead is particularly fortunate in having so fine a lung for the Metropolitan ratepayer as the Heath, representing an area of about 336 acres.

However, I think there is much to be said in favour of a number of small open spaces, if such could be found in the immediate neighbourhood of populated districts, easy of access to the very young, who should be provided with playing and breathing grounds for daily use near at hand, in preference to large open spaces or commons situated possibly a mile or two away.

Tree planting is a branch of this department, and how the appearance of the ordinary London street has been improved during the past few years in this respect is manifest to all.

In the public thoroughfares we have some 3000 trees, chiefly planes and limes, which are found to flourish best in London soil and atmosphere.

The adoption of the Free Libraries Act in 1896 has considerably added to our work. A central library has been erected from a design (by selected competition) at a cost includ-

ing land of 7249*l*, and also three branch libraries, from my designs, at a cost of about 10,000*l*.

This, as will be seen, is an entirely new branch of duty connected with the engineer's department, as also are the works now thrown upon him by the same Act in connection with baths and washhouses, cemetery ground, etc.

The last topic I have to mention relates to electric lighting. As no doubt most of you are aware, Hampstead has taken a foremost position in regard to this important branch of municipal work, for in the year 1892, under the advice of Sir William Preece, a provisional order for carrying out the installation and supply to the whole area of the district was obtained.

This is being gradually effected with so far considerable financial success, and I hope during my term of office as your President, my friend Mr. Cottam, M.I.E.E., electrical engineer to the vestry, will favour this Association with an account of the undertaking and an opportunity of inspecting the station.

I know it has been considered by some that the engineer and surveyor to a vestry should have a *quasi* control over the management of this department; but upon this subject I hold strong views, being of opinion that the ordinary duties of a surveyor fully occupy his time, and that such a department, requiring as it does a most perfect technical knowledge in all its branches, should be administered by an electrical engineer entirely independent of the municipal engineer.

The extent of the undertaking in my own parish, together with its great responsibilities, have demonstrated the inadvisability of attempting to combine in any way the two offices, thus fully confirming my original views.

I am afraid that the foregoing remarks will strike many Members of the Association as dealing only with well-known subjects and well-beaten paths, but I must ask you to treat with kind consideration the lack of novelty such as many of the giants of the profession (my predecessors in office) have been enabled to lay before you. The duties of the engineer and surveyor are of so multifarious a nature that he must train his mind to grasp not only the greatest but the smallest matter coming under his notice. Whilst his chief attention may be directed to some important engineering scheme, he must by no means be deaf to the cries of more water, improved dust removal, sewer emanations, blowing about of waste paper, removal of

snow in its season, and the thousand and one grievances which the long suffering ratepayer is liable to endure, with his oft repeated cry that "something must be done." Thus when one looks back upon years of active public service one need not wonder much that the oft talked of "bed of roses" has not been his lot.

The mention of many of these matters may appear at first trivial and unimportant, but I consider that an Association such as this might be well engaged and would perform a very satisfactory work if some of the matters on which I hawe touched were more fully considered, so that upon a plain issue we might be prepared with a consensus of opinion as to what is or what is not the right thing to be done under certain circumstances, and in order that our Association as a body might speak with no uncertain voice as to the best method of carrying out the various important branches of local government upon which the public might very reasonably look to it for guidance.

The Members of this Association cannot but be struck with the loyalty and good feeling which has always characterised our dealing with one another. All information is freely given and exchanged; the results of our labour, sometimes the work of years of experience and anxiety, is ungrudgingly given for the benefit of our colleagues. The recent case of the readjustment of the boundaries of the districts of the new corporations illustrates this point, where the different views were fought out in a fair spirit and with a total absence of overreaching or unreasonable contention.

The position of the Association must be a source of great satisfaction to its Members; during the past few years its number has been considerably augmented, and its importance acknowledged by the public, kindred professions, and members of the various departments of the public service with whom it has been brought in contact. The total number of Members at present is 954, distributed as follows:—

In England and Wales	877
In Scotland	13
In Ireland	32
Foreign parts	32
Total	954

The handsome volume of Proceedings so ably edited by our Secretary, speaks in no uncertain tone of the increasing useful-

ness of the work of this Association; the yearly publication of the papers contributed and read render the volume a text-book of considerable value to Members, both at home and abroad.

The question of increasing the usefulness and benefits of the Association by extending the limits of the privilege of admission has been on various occasions under the consideration of your Council. The matter is one demanding the most careful thought in connection with the foundation of this Association as laid down in the Articles and Bye-Laws.

During the past year a most desirable step has been taken in the establishment of an Orphans' Fund, an object which we all so much desired but approached with a certain amount of doubt as to its practical success.

All honour is due to the promoters as also to the subscribers who have enabled your Council to establish the fund on a sound financial basis, and I may be allowed to express the hope that every Member of this Association (who may not have already subscribed) will at once give in his name as an annual subscriber, yearly subscriptions being after all the backbone of all philanthropic schemes. The fund we hope may prove some help, when any of our Members may be called away leaving those dependent upon him in straitened circumstances.

We are still hoping for the success of a Superannuation Bill—the permissive Bill, if I may use the expression, of 1866—from which so much was expected by Metropolitan Members, being apparently difficult of interpretation or of application as shown by results in some recent cases. Whilst upon this subject I must mention the case, no doubt fresh in all our memories, of Mr. Angell, the much esteemed founder of this Association, a gentleman whose professional attainments are of the highest order, who was after long and faithful service dismissed by his corporation almost at a moment's notice, and, as the case at present stands, with no redress from this altogether unjust treatment. Our Council, as was their bounden duty, endeavoured to take action to protect his interest, and the solicitors were consulted, but could recommend no satisfactory course of action. This case alone indicates how essential it is that we should seek some safeguard against such treatment, and one can only hope that a line of action similar to the one in question may not be pursued by any one of the new corporations to the formation of which we are looking forward.

We have sustained a great loss during the past year in the death of one of the Past Presidents, Mr. Edward Pritchard, a gentleman eminent in his profession, and one who has rendered very great assistance and devoted a considerable amount of time to the objects of this Association, more especially in regard to the annual examination, in the carrying out of which he was always ready to give his most valuable services. The Council forwarded some time back a vote of condolence in suitable terms to the relations of the late Mr. Edward Pritchard.

In conclusion, permit me to thank you for the patient and kind attention with which you have listened to me whilst reading an address which I am afraid will be considered by many somewhat of a homely nature, and a reiteration of well-known subjects possibly very much better understood by you than I have been able to lay them before you.

However, it is well at times to look fairly and squarely at our ordinary everyday work, with a view to advancement and improvement, for I take it that the primary aim of this Association is the maintenance of the status of its Members, and the diffusion of knowledge for the common good. This can only be attained by good work well and efficiently carried out by them, so that we may exhibit the marks of a man, so aptly described some time back in one of the quarterly reviews, viz. "That he uses his own eyes for seeing, his own common sense for judging, and that his actions spring from his own will."

It is a trite saying that "the past is always secure," and I shall endeavour during my tenure of office to protect the present and to maintain the prestige of the Association, handing down to my successor the traditions it has already acquired unimpaired; but in order to do this, I must rely upon the kind support and sympathy so loyally given heretofore by you to your Presidents, and to the assistance and sound guidance of my Council and of your highly esteemed Secretary, who are ever mindful of the best interests of the Association; then shall I feel sure that I shall not entirely fail as your President.

CONDITIONS NECESSARY FOR SUCCESSFUL PURIFICATION OF SEWAGE BY LAND TREATMENT.

By H. ROYLE, Assoc. M. Inst. C.E.

The Author desires to endorse the remarks made by Colonel Jones in his paper on Sewage Farm Management read at the Annual Meeting at Halifax in 1895, in regard to the very limited knowledge possessed by sewage-farm managers as to the proper treatment of sewage, and how few there are who thoroughly understand the matter. Colonel Jones said he could count on his fingers the self-educated sewage-farm managers who did justice to their charge, and we know that if any such authority requires such a manager he is rarely to be found. Colonel Jones suggests technical education at model sewage farms, for managers and watermen, where a register of qualified persons could be obtained.

The Author, having had fifteen years' experience in sewage farming with crude sewage on the Broad Irrigation principle, after having laid out a farm of forty acres, is desirous of imparting his experience and knowledge for the benefit of the Members of this Association.

In the first place, it is well known that a good soil is of the utmost importance for the due and proper treatment of sewage; and must be combined with efficient underdrainage in order to produce a good effluent; nevertheless when these two essentials are at hand, the desired results are not always obtained. This may appear strange, yet such is the fact; and why is this so? The Author's object is to endeavour to supply this information from the experience gained on the Stretford sewage farm, which is undoubtedly a first-class farm, and is justly considered as the model sewage farm in the watershed of the joint committee of the rivers Mersey and Irwell.

The scheme is a pumping one, and the sewage is received

into a large receiving tank. It is then pumped into a cistern, from which it flows through an underground cast-iron rising main, and underground earthenware carriers, having hydrant chambers and penstocks for distribution of sewage over the land as may be desired; thus, so far, this arrangement is common to most sewage farms. The land varies as to quality, the soil being an alluvial deposit, and has a gentle fall from the west to the north; the under-drains on the northerly half of the farm are not so deep as on the westerly half, and the soil is of a slightly stiffer nature; it is therefore not so suitable for sewage treatment as the westerly half.

On first draining the land, agricultural draining tiles, some of six inches and some of four inches in diameter, were laid at a distance of twenty yards apart (agricultural tiles the Author considers are the best on account of their porosity); these, after a time, were found to be inadequate, so that intermediate drains are being laid as time in winter permits. Originally, the whole of the land was in grass (old meadow-land), and in covering up the drains, the green sod was turned upside down and laid immediately on the tiles, and the filling in well rammed up to the surface. Twenty-five acres of this original surface was sewaged for three years without any tillage whatever, and during this period a first-class effluent was produced. In due course the herbage became coarse under sewage treatment; the land was then ploughed up, and a regular rotation crop has been carried on up to the present time. After ploughing, defects began to show themselves: occasionally there was not so good an effluent as before when in grass. This was found to be due to the rotting of the fibres of the sods, which caused a small cavity between the earth and the tiles; these drains have since been opened out, the sod portion removed, and the ground thoroughly well rammed from bottom to top as solid as possible. The drains on the farm vary in depth from three and a half feet on the northerly side, to five feet on the westerly side. Previously to taking out the rotted sods on the drains, it was necessary to carefully avoid putting sewage over the line of some of them. This was easily done, as the whole of the drains on the farm are laid in parallel lines, not in herring-bone fashion—which latter is, in the opinion of the Author, on a sewage farm a decided mistake—in which case keeping the sewage off the line of pipes would have been an impossibility.

On sewage farms, worms and rats occasionally are a source of great trouble and annoyance by their burrowing, especially where the drains are shallow, causing small holes which allow the sewage to get into the drains without having been filtered through the land, and thus a bad effluent is the result. In dealing with an infected worm area, of which we have had numerous experiences, we pump the very strongest sewage we can from the bottom of the tank, and on some occasions, previous to closing the land with strong sewage, have sunk down to the drains and temporarily blocked them up, and have thus been so far successful in killing them that the land has again continued to produce as good an effluent as before. The worms do not die in their holes, but come to the surface. They have caused an imperfect effluent even when the drains have been as much as four and a half feet in depth.

It is often stated that land becomes sick through the application of sewage; this is no doubt a fact, for if sewage is applied continuously week after week and month after month without aëration and rest, it will become sick, as the micro-organisms in the soil cannot live in water-logged ground. In consequence many farms have been condemned unjustly as not being successful. As a matter of fact, a recent analysis of the soil of the Stretford sewage farm has proved of better quality after fourteen years of regular sewaging than that of the extension land which had only been sewaged a few times during twelve months.

Having thus in a general way described our mistakes, the Author desires to say what he considers essential in making a sewage farm or filtration area successful.

No drain should be laid if possible less than five feet deep, as it is found that worms will burrow as far as three and a half feet in depth.

In cutting drain trenches through land, it will invariably be found intersected with old draining tiles and spit drains. It is of the most vital importance that these should be carefully noted when cutting the trench, and great care taken to cut them off at least four feet on either side of the new trench, otherwise trouble will begin as soon as the sewage is put on the land. As these old trenches will be found to be only about eighteen inches or two feet in depth, it will be seen that a ready unknown carrier is there to convey the sewage to the

drains without its having gone through sufficient depth of land to ensure proper filtration.

Again, it is important that the drains should be well and truly laid and with close joints, and in filling in the earth it is of the utmost importance that a layer of the best soil should be placed on the tiles. As to filling in and ramming, this cannot be too well done; in fact the ground over the newly laid tiles should be made as solid as before displacement; this precaution is of the utmost importance, as afterwards, if not properly rammed and made solid, no amount of sewaging will suffice to consolidate sufficiently for effectual sewage treatment.

Having already pointed out the great importance in making the ground over the drains perfectly solid, and cutting off all lateral old drains, the Author desires to point out another fatal error that is made on some sewage farms and filtration areas, viz. the placing of gravel, sand or cinders on the tiles, or using perforated pipes, with the object of giving, as is generally supposed, a better filtrating medium. This practice is, of all the mistakes that can be made in regard to sewage treatment, the most disastrous; errors of judgment like these have caused many sewage farms to be failures in producing good effluents.

This question of putting cinders on drains must not be confounded with bacteria beds formed of cinders or coke breeze, as the two operations for producing good effluents are not identical. The fact must not be overlooked that the drains are always acting and in operation soon after the application of sewage on the land, whereas bacteria beds have no underdrainage, except such as is required at the bottom of the beds, for the purpose of draining them after complete saturation and aëration, being regulated at will by penstocks after the prescribed time required for filling, saturation, emptying and rest. Unless drains are laid as pointed out, failures are bound to occur; even when laid as suggested they will require frequent examination and re-punning, as and when they suddenly go wrong. Want of knowledge in regard to badly laid drains has undoubtedly been the cause, in some cases, of sewage farms failing to produce a good effluent, although having ample and suitable land for the purpose. Treatment by chemicals before applying the sewage on the land is then resorted to, instead of first putting the drains in order. No doubt many sewage farms are in disrepute

solely from want of this drain knowledge, it being a great mistake to suppose that when drains are once laid they will act properly for all time to come, even when in the first instance well laid and well rammed.

In the management of a sewage farm or filtration area, it is essential that the manager should keep a strict watch on his effluent and his drains. This can be done if the drains are laid in parallel lines, having examination pits or eyes at the junctions with the main effluent drains, or where they may enter separately into an open channel; it is then possible to ascertain the whereabouts of any drain that may be working imperfectly, and at once to take steps to remedy it, viz. by taking out the soil immediately over the drain and re-punning it as if a new drain was being laid. This is a necessity that will frequently occur, and must be attended to if a good effluent is to be maintained.

In laying out a sewage farm or filtration area, the Author would impress on all who are called upon to undertake these important works, that all drains should be laid in parallel lines, and in the direction of the greatest slope of the land. On no account should the work be let by contract, except the trench cutting; also every care should be taken in laying the tiles and the filling in and ramming solid as before mentioned, for unless this be done a satisfactory effluent is an impossibility; and even after these precautions have been taken it will be found that frequent imperfections and unsatisfactory effluents will occur during sewaging of the land, through worms, rats and other causes; and the remedies mentioned must be resorted to.

As regards a sewage farm manager, Colonel Jones remarked there are few who do justice to their charge.

This is undoubtedly true, for unless a manager is thoroughly well up in land drainage—and this, in the opinion of the Author, combined with good land is the main secret of producing a good effluent—however well he may be qualified as an ordinary farmer, unless he is well versed both as land drainer and farmer, and takes a pride and interest in his work, trying to produce suitable crops combined with a good effluent (the latter not to be sacrificed for crops), he will never succeed as a sewage farm manager, as such an occupation is so different to ordinary dry land farming as generally understood.

The Stretford sewage farm consisted of forty acres up to two years ago; since then it has been extended to seventy-seven acres. Fifty-seven acres are sewaged on the broad irrigation principle with crude sewage with a dry-weather flow of two-thirds of a million gallons a day, from a population of about 10,000 people, and since the joint committee of the rivers Mersey and Irwell began analysing sewage effluents six years ago, the average analysis of twenty-three samples was ·30 of a grain per gallon on the four hours' test.

DISCUSSION.

Mr. A. M. Fowler: It is some years since I paid a visit to this farm, and I should like to ask whether the land is level, what means there are of examining the underdrainage, and if Mr. Royle floods the land, or gives it a dressing of sewage.

Mr. MacBrair: I should like to ask as to the quality of the sewage treated. As I take it that a dry weather daily flow of 650,000 gallons to 10,000 people is a highly diluted one; this may account for the acreage taking so comparatively large a quantity of sewage?

Mr. Turley: I notice that the Author considers agricultural tiles best for draining a sewage farm on account of their porosity. Surely they are not so good as glazed socketed pipes laid with open joints. I should like to know what kind of crops are grown on the farm, and the cost per acre of laying out the land, and the annual expenditure and receipts of the farm.

Colonel A. S. Jones, *V.C.*,: I have been harping for many years upon the proposition of this paper—that the subject of sewage farms is very much one of management. The Author refers to underdrainage, only one of the many points which require the attention of the engineer in laying out a farm. I would insist upon the laying out of all sewage farms by day labour, and under personal superintendence of a specialist engineer-farmer. It can never be done satisfactorily by contract, as the Author has truly said. Mr. Royle has referred to a paper of mine advocating the education of managers and labourers employed on sewage farms. I should like to see that education carried even further than the questions of drainage and of cropping, for there are so many contingencies to deal with on

a sewage farm. The ordinary farmer has to contend with the uncertainty of weather, but the sewage farmer has infinitely more varying conditions to contend with. I regret the attention which has been too much given to the theory of the thing to the neglect of practical management. There is too much tendency to lay down fixed rules, irrespective of the land, the quality of the sewage, and the local circumstances. A great deal of discretion must be left to the manager, and he must be encouraged to take an interest in his work—not only the manager, but every hand employed on the farm. The farm labourer, who is the backbone of the sewage farm, and who can be easily educated to the work, is dying out very fast, and it is very difficult to fill his place, under existing conditions.

Mr. J. P. SPENCER: I think if any good is to come from the discussion of the question of the education of sewage-farm managers, it would be well for the Council of the Association to formulate suggestions as to a course of instruction and send them out to the County Councils. It might be suggested that in the work of technical education in which County Councils are engaged, they should turn their attention to classes in the management of sewage farms. Technical education is now a very fashionable commodity, to which large sums of money are voted in nearly every county and county borough, and they might, with advantage to the community, turn their attention to instruction in this important subject. Many of the County Technical Schools have classes for dairying and other branches of farm work, but this important question of sewage farming, which requires technical knowledge, has been overlooked. A discussion here by ourselves for weeks would have no practical effect, but if the Council of the Association will take it in hand and send out suggestions to the County Councils, it would have considerable weight.

Mr. R. J. ANGEL: I regret that I have to object to many of the deductions made by the writer of the paper. My opposition to broad irrigation is that too much attention is often given to the crops at the expense of the sewage. It is a very common thing while the crops are in full growth to find that it is impossible to put sewage upon the land, and if left in negligent hands the sewage is allowed to run away and pollute the stream. In the case of this farm the drains are deep for ordinary unglazed agricultural drain pipes, and are likely to retard the

treatment of the sewage. The sewage will not percolate through the land at the speed at which it is expected to go, and will therefore cause serious trouble, and the Rivers Pollution Acts are in danger of infringement. Then I note that the pipes are of the unglazed agricultural type. Now as sanitary engineers we at once condemn a rough surface where we are working with a flat gradient, but here, on a sewage farm, where the flow is small and the gradient flat, we are told that the rough unglazed surface of the agricultural drain pipe is best adapted for the successful purification of sewage by land. I disagree with that deduction, though I am speaking in the presence of those who have had more experience than I have. Then a great point is made of the fact that the pipes are porous. Do we not understand that the soil is composed of grains of infinitesimal texture, and is it not possible that these minute grains may in the course of years find their way into the pores of the pipes, and by choking them up render them inadequate for their purpose? Then we are told by the Author that there is a close joint. From what I know of an agricultural drain pipe, a close joint cannot be obtained unless the soil is rammed tightly round, and even when every precaution is taken to make the joint as tight as possible, some grains of earth will still get in through the joint; but if, as the Author states, the soil is rammed tightly round the pipe, it appears to me that he is using every means to prevent the water from finding a passage, not only through the joint, but also through the porous surface of the pipe. I have had a considerable experience in this class of work, and speaking from that I prefer a glazed socketed pipe with holes on the upper half. In the case of this farm no gravel is put round the pipes. I have seen a considerable number of sewage farms, and in every case glazed socketed pipes have been used, covered with gravel or ballast. That effectually prevents any grit from getting into the drains. Main pipes of 6 inches and 9 inches in diameter are usually laid on sewage farms with 4-inch branches. At Walsall the pipes are of those sizes, and they were laid with a fall of 1 in 500 where the ground was comparatively level. The 6- and 9-inch main pipes were laid a distance of 50 yards apart. The distance apart of these drains conduced to the satisfactory working of the farm. The branches were laid on level ground half a chain apart, and on sloping ground a chain apart, and to a "herring-bone" pattern.

I have seen a considerable number of pipes taken up (from farms and other places) where fungus has grown inside the pipes, and what better adhering surface could one find than the rough interior of an agricultural drain pipe? Any sewage which contains a proportion of sulphur, which has not been counteracted by an alkali, is an unfailing means of producing a growth of fungus, which will certainly cling to the sides of the pipes and choke them up. Nothing is said in the paper about the retention of the fæcal matter, and we must take it that it is allowed to flow on the land. The Local Government Board in 1893 issued an order that where farms were laid out on the broad irrigation principle, some system of straining the fæcal matter should be adopted.

Referring once more to the question of filling-in round pipes, some Members may ask why I speak so strongly in favour of gravel or ballast as against ramming the soil around the agricultural pipes mentioned in the paper. The Walsall sewage farm was laid out on the two systems of intermittent downward filtration and broad irrigation twenty years ago. It was noticed that one portion of about 24 acres did not, even from the beginning, work as satisfactorily as the rest of the farm, and on examination it was found that the pipes, though glazed and having about 32 holes of $\frac{1}{8}$-inch diameter along the upper half of the perimeter, were laid without any gravel or ballast around them, and that the soil was rammed tightly around the pipes.

When the original specifications were looked up it was found that these pipes ought to have been covered with gravel or ballast similar to that done in the other parts of the farm. The portions which were covered worked all right, but where the gravel, etc., was omitted the ground had become water-logged.

Mr. T. Walker: I think the irrigation farm under consideration can scarcely be called one of broad irrigation, but rather one of intermittent downward filtration, and I will give you a brief description of the broad irrigation farm at South Norwood, Croydon. It is unfortunately a very stiff clay farm. There were four brickfields on three sides of the farm. We have 150 acres of land on which to deal with the sewage of 21,000, and 100 acres out of the 150 have this rank clay subsoil. I recently had a hole dug and found 10 inches of soil, and at 12 inches below the surface there was not the slightest mark of any sewage

reaching there. Eighty out of the 100 acres of clayland are very flat, with a fall of only 1 in 500. Then the effluent from the farm goes into a very shallow and small watercourse; in fact, in dry weather the effluent makes the flow. We have practically no underdrainage. A few plots are drained about 18 inches deep to dry the land more quickly when the sewage is taken off the plots. We have been dealing with sewage on this farm now for 36 years, during which time it has been taking the sewage of the population I have mentioned, and the farm is doing its work efficiently to-day. I am speaking of broad or surface irrigation. In the scheme described by Mr. Royle underdrains seem to be the life and soul of the matter, whereas, the dealing with solids and the laying down of the land so that the sewage flows over it to the catch-up carrier at the bottom of the plot without ponding are of equal importance.

Mr. E. G. Mawbey: In all my experience with downward intermittent filtration, I have found that one of the great things is to keep the sewage off the top of the drains. Of course that is a totally different thing to Croydon, and to what we have at Leicester, where we must have proper drainage. The great thing is to do with as few drains as you can, even for intermittent filtration, and to prevent the sewage flowing over them. We use agricultural land pipes for all the drainage at Leicester, and my experience is such that I would rather have good well-burnt agricultural drain pipes than stoneware pipes spoiled by holes all along the top of them.

Mr. A. M. Fowler: I thoroughly coincide with the Author of the paper that, however well an engineer may design his work, if he has not a good manager it fails. Some managers will flood the land with about 18 inches of water, or about 1800 tons per acre. However well drained your land is, such a great weight of water forces the small particles of soil through the joints of the drains. Take for instance a waterworks filter bed. If you bring the water through, and syphon it nearly to the top, you get a splendid effluent, but if you force the water through land with a full head of water you get a scour. Some farm managers, in their ignorance, do this. To prevent it you should have as little pressure as possible upon your drains, and the wider you can get your drains apart the better filtering media you provide. By flooding the land you destroy the microbes. I have recently completed some large sewage farms, and with

regard to the practice of putting gravel round the drains, I would not do it again, because I find the sand gets into the drains quicker. I do not believe in the use of socketed pipes for land drains, they are very well for main drains. As to the theories which have been put forward by some of our friends, I have nothing to say, because I prefer to speak from practice. I have great pleasure in proposing a vote of thanks to Mr. Royle for his short but valuable paper.

Mr. W. Harpur: As to underdraining, I quite agree with what Mr. Fowler has said. The further you can keep your underdrains apart the better. In the case of downward intermittent filtration, I think Mr. Walker said there should be no drains under the land, but that they should be covered by the footpaths, so that there should be no direct percolation of water into the drains. That is quite correct. I happened to be employed on the first intermittent downward filtration scheme carried out at Merthyr Tydvil, when Mr. Bailey Denton was called in. The works carried out there have been in operation for thirty years, and after that lengthened period, so long as the farmer manages his work as he should do, they there continue to have an absolutely perfect effluent. There is no surface water which comes within 4 feet or 6 feet laterally of the drains. The quality of the effluent depends a great deal upon the kind of subsoil drains, and also upon the soil; at Merthyr we had a perfect soil, Mr. Angell said he had fungus growing in the effluent drains. The reason for that is that he has not a perfect effluent. In draining filtration areas, if it is possible and the soil is suitable it is most desirable to avoid having any drains under the land which is to receive the sewage. There can be no hard and fast line as to the method of treating sewage upon land, you must take each case upon its own merits and the circumstances of the case; there is such a variation of soil to deal with, that you must take into consideration the circumstances of the land and prepare it accordingly. The great point is that you cannot treat two farms upon the same hard and fast methods of laying out, and in the matter of treatment of the sewage the same remark applies.

Mr. J. E. Wilcox: I cannot agree with Mr. Harpur as to the desirability of not having any drains laid under land taking the sewage. I have known three or four cases where the land is not underdrained, and in every case it was found in practice

absolutely necesssary to lay drains before any good results could be obtained, although the land was of a specially porous nature. This discussion has turned upon the question of drains and their construction, but the success of land treatment depends more upon the area available, the nature of the subsoil, and the quantity of sewage to be dealt with upon a given area, and the method adopted of distributing it, the last being the most important point. One speaker mentioned the Walsall sewage farm, but Walsall is more or less stiff land and cannot possibly be compared with the scheme under consideration, which is an alluvial bed. With regard to gravel over drains which one speaker holds is essential, I have put in many miles of drains in this way, but probably should not do so again as the result of my observations shows that it is seldom satisfactory, and leads to the sewage flowing direct to the effluent drain without properly passing through or over the land. The question of gravel or no gravel is by no means of such importance as the question of distribution of sewage.

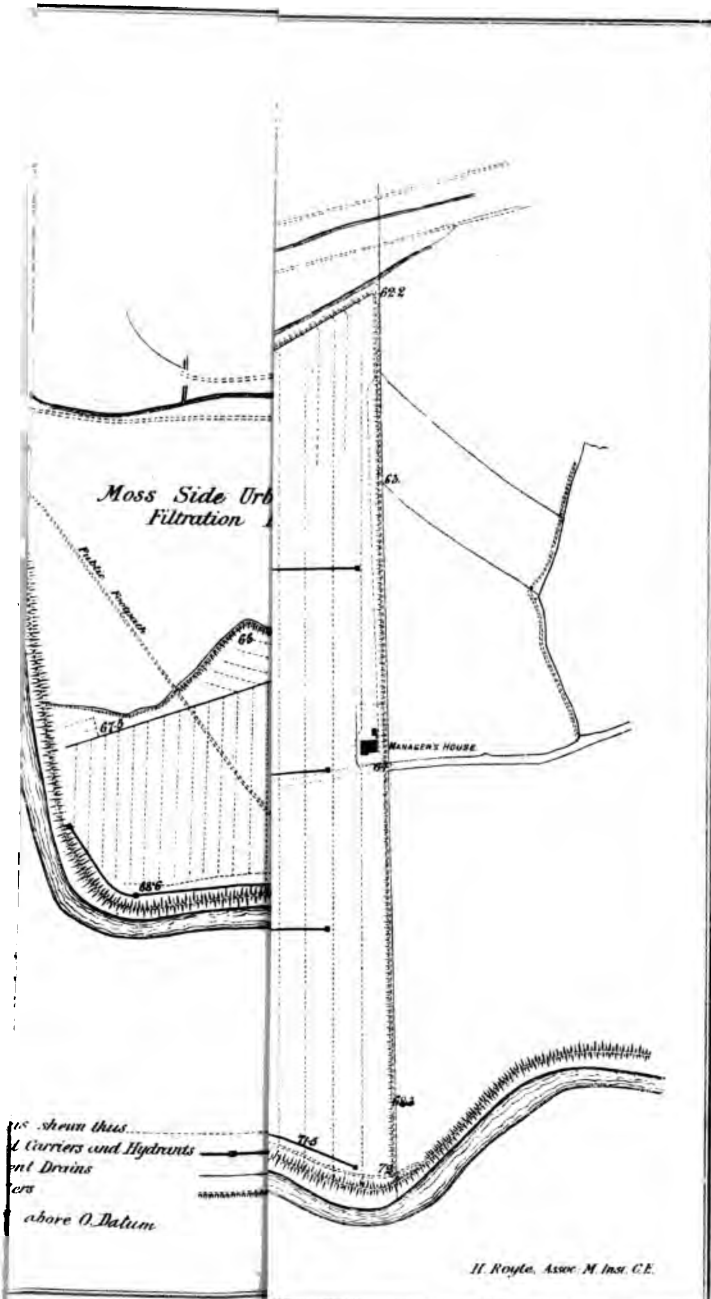
Mr. A. D. Greatorex: I quite agree with Colonel Jones as to the management of sewage farms. I think all sewage farms should remain under the absolute control of the engineer who lays out the farm. I am pleased to have the entire management of a sewage farm of 230 acres. I have no farm committee, the farm bailiff is entirely under my direction, and therefore I get good results. I think if the sewage farm were placed entirely under the control of the engineer to the Local Authority, then we could educate the farm bailiff to carry out the work in an efficient manner, and sewage farms would not have such a bad name as at present. He would then be able to study the question of crops and of sewage treatment, which should be worked together.

REPLY TO DISCUSSION.

Mr. Royle (*communicated*).

In replying to the discussion on my paper, I desire to thank the gentlemen present, not only for the evident interest they have given to it, but for the vote of thanks which they have accorded at the instance of Mr. Fowler.

I am glad that Mr. Fowler emphasised my point that unless a sewage farm had a good manager, the work of the best engineer



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would fail. With regard to Mr. Turley's queries, I have pleasure in giving the information asked for.

Underdraining, twenty yards apart, including main drains, cost 13*l.* per acre. Underground carriers and cast-iron rising main cost 16*l.* an acre. Grubbing up hedges and levelling cost 4*l.* an acre. Two cottages, 350*l.* Manager's house, 430*l.* Stables and shed, 350*l.* Receiving tank, about 1000*l.* Flood fenders, on three sides of the farm, 100*l.* The usual crops grown are cabbages, mangolds, potatoes, ryegrass, and 10 acres of osiers, and experiments are now being tried with rhubarb for forcing purposes in winter.

I would remind him, however, it is not my sole object to produce the greatest profit out of the farm, for I have a due regard to the purity of the effluent; previously to the extension of the farm it paid its way, but since more land has been added, the last two years show a profit respectively of receipts over expenditure of 387*l.* and 492*l.*; these items do not include value of stock on hand or growing crops.

I am glad the large experience of Colonel Jones allows him to confirm my views as to management. I am afraid, however, he has not fully estimated the importance of underdrainage, which, although only one point, is a most important one in my practical experience of over fifteen years, and in fact a necessity in farms of limited areas.

Of course it is well known that the quality of the land has much to do with the success of a farm, and if you add proper drainage and good management, you have the necessary conditions to successful sewage treatment.

Mr. Spencer's suggestion seems a good one, and if County Councils would grant prizes to those farms which are successfully managed and produce good effluents, it would be a great encouragement to managers.

I appreciate Mr. Angell's criticisms as to the use of glazed pipes in preference to the agricultural unglazed pipes, and whilst there may be isolated cases where glazed pipes are to be preferred, yet I maintain that in the generality of cases the unglazed agricultural pipe has an advantage in being porous, allowing the effluent to percolate through the pipe. Whereas the glazed pipe, being impervious, will only drain at the joint, and is therefore not nearly so efficient.

Of course I lay great stress upon the necessity for unglazed

pipes to be of good quality, true in shape, and to be properly jointed and packed with soil and made tight; this jointing, laying, and packing equally applies to glazed pipes if a good effluent is to be had. Where gravel or sand is employed (especially if the pipes are not well and truly laid, etc.), they are liable to become choked, and cause the fungus he complains about to accumulate. Fungus is present in drains owing to sewage not having been properly filtered before getting into them, and does not grow when sewage is properly filtered.

I consider that gravel, sand or cinders do not filter sewage like soil on the pipes, they drain too quickly to obtain a good effluent, and it is worth noting that Mr. Fowler, as the result of his large experience, says he will never put gravel round drains again; and for his information I have to inform him that the land only receives dressings of sewage, and is rarely flooded except for short periods in winter.

In answer to Mr. MacBrair, the sewage is all from a water-closet property, and is of a fairly strong character, being diluted with subsoil water.

I note that Mr. Walker at the South Norwood farm does *not use* underdrainage, but allows the sewage to flow over the land into a ditch. Of course, it is possible over an unlimited area of land (especially if grass land, which will purify considerably more sewage than the same quantity of arable land is capable of), it is possible to do without underdrains; even then I should like to know something about the purity of the effluent. We do this on the Stretford Farm to a limited extent, after passing sewage through the osier beds the excess flows over ryegrass, and finally drains through the land into the effluent drain; this ryegrass is made into fodder. I note that Mr. Mawbey agrees with me as to using good well-burnt agricultural pipes in preference to glazed pipes with holes or perforations on the tops; these perforations allow the land to drain too quickly; especially if laid shallow, a good effluent is unattainable.

In the bulk of places near cities and towns, of which Stretford is one, the area is limited and underdrainage becomes a necessity, with the advantage that we probably get a purer effluent.

With Mr. Harpur I agree that the drains should be as far apart as possible, in fact no drains at all if this were possible;

but I would remind him in that portion of my paper recounting my errors, I discovered I had the drains *too* far apart, and had, in consequence, to insert intermediate ones. Even Mr. Wilcox appears to have found from experience that he had got his drains too far apart also; that gentleman, however, considers the successful treatment of sewage rested rather upon the area of land available and the quality of the sewage than upon the method of distribution; but how about those farms which are successfully managed upon a limited area with the aid of proper underdrainage?

Finally, I consider, with Mr. Greatorex, that the borough engineer should have absolute control over the scheme, and work in conjunction with an experienced sewage-farm manager.

In conclusion I have to thank those who have entered into the discussion for the benefit of their views, which seem generally to confirm what I have laid down, viz. that no hard and fast rule can be applied; for the discussion has shown that in isolated cases, and over an unlimited area, underdrainage can be dispensed with, whereas in limited areas underdrainage becomes an important factor, and this together with competent management and suitable soil, practically makes all the difference between successful and unsuccessful treatment of sewage; also bearing in mind that a good effluent is not to be sacrificed for the purpose of securing a profit on the crops.

The farm is within an easy distance of Manchester, and if any Member is desirous of making an inspection, every facility will be given by the Author, who would be pleased to explain further the working of the farm.

THE RATE OF RAINFALL.

By JOHN P. DALTON, Engineer and Surveyor to the Ryton Urban District Council.

The rate of rainfall is a subject of the greatest importance to drainage engineers, and one which does not appear to have received the attention which it deserves.

The Author has been engaged during several years in making careful observations, with the view of ascertaining the different rates at which rain of varying degrees of intensity is deposited.

The gauges used are of the direct reading type, consisting of a funnel, of ordinary rain-gauge pattern, delivering into a glass tube, about eighteen inches long, fixed against a graduated board; the relative areas of funnel and tube being so proportioned, that one-hundredth of an inch of rain on the funnel raises the water level in the tube about three-tenths of an inch.

The gauge being set up outside a window, the scale can easily be read from inside at a distance of several yards.

The time and attention required render the compilation of a sufficient number of observations to form a reliable basis a somewhat arduous and protracted undertaking, which might be simplified by the use of a self-registering gauge; but the advantages of being able to SEE the rate of fall from minute to minute, and to note the character of the rainfall at each reading, would thereby be to a great extent lost.

It will be advisable to give here, in detail, a few selected observations, with the rates of fall, and notes as to the character of the rainfall, to facilitate reference to which the following scale is used, viz.:

Very slight rain	*a*
Gentle rain	*b*
Moderate rain	*c*

Steady rain	*d*
Heavy rain	*e*
Very heavy rain	*f*
Exceptional fall	*ex*
Variable fall	*v*

(1) June 20, 1897.—Drizzling rain.

Time.		Fall.	Character.	Rate of Fall.
hrs.	min.	inches.		inches per hour.
0	40	·01	*a*	·015
0	30	·01	*a*	·020
0	55	·03	*a b*	·032
2	5	·05		·024

(2) May 1, 1899.—Moderate rain.

Time.		Fall.	Character.	Rate of Fall.
hrs.	min.	inches.		inches per hour.
3	26	·25	*c*	·072
0	8	·01	*c*	·075
0	12	·02	*c*	·100
0	22	·04	*c*	·108
4	8	·32		·077

(3) May 21, 1898.—Steady rain.

Time.		Fall.	Character.	Rate of Fall.
hrs.	min.	inches.		inches per hour.
0	5	·01	*d*	·120
0	5	·01	*d*	·120
0	10	·02	*d*	·120
0	5	·01	*d*	·120
0	15	·01	*c*	·040
0	40	·06		·090

(4) May 21, 1898.—Slight to heavy rain.

Time.		Fall.	Character.	Rate of Fall.		
hrs.	mins.	inches		inches per hour		
0	30	·01	*a b*	·020		
1	10	·03	*a b*	·025		
0	4	·01	*d*	·150		
0	3	·01	*d*	·200		
0	4	·02	*e*	·300		
0	1½	·01	*e*	·400		
0	2½	·01	*e*	·240		
0	2	·01	*e*	·300	·214 (42 min.)	
0	3	·01	*e*	·200		
0	3½	·01	*e*	·171		
0	9	·03	*e*	·200		
0	4½	·02	*e*	·266		
0	5	·01	*c*	·120		
0	14	·01	*b*	·043		·208 (1 hr. 35 min.)
0	10	·02	*c d*	·120		
0	4	·01	*d*	·150		
0	1½	·02	*e*	·800		
0	1	·01	*e*	·600		
0	0½	·01	*f*	1·200		
0	3	·02	*e*	·400	·261 (39 min.)	
0	3½	·01	*d*	·171		
0	1	·01	*e*	·600		
0	2½	·01	*d e*	·240		
0	2	·01	*d e*	·300		
0	10	·04	*d e*	·240		
0	9	·01	*c*	·066		
0	24	·01	*b*	·025		
3	48	·39		·102		

(5) October 1, 1899.—Moderate and steady rain.

Time.		Fall.	Character.	Rate of Fall.
hrs.	mins.	inches		inches per hour
16	0	1·11	*v*	·069

(6) June 7, 1900.—Variable rain.

Time.		Fall.	Character.	Rate of Fall.
hrs.	mins.	inches		inches per hour
0	9½	·05	*e f v*	.315
0	1¼	·05	*f*	2·400
0	2	·04	*e f*	1·200
0	2	·01	*e*	·300
0	3¾	·02	*c d e v*	·320
0	8½	·02	*c d*	·141
0	4	·01	*d*	·150
0	7	·01	*c*	·085
0	8	·01	*c*	·075
0	46	·22		·286

(7) August 16, 1898.—Thunder rain (not excessive).

Time.		Fall.	Character.	Rate of Fall.	
hrs.	mins.	inches		inches per hour	
0	2¼	·04	*f*	1·066	
0	1¼	·04	*f*	1·920	
0	1½	·04	*f*	1·600	1·260
	1½	·03	*f*	1·200	(10 min.)
	2½	·04	*f*	·960	
	1	·02	*f*	1·200	
0	3¼	·03	*e*	·552	
0	2¾	·01	*e*	·218	
0	16	·25		·937	

(8) June 11, 1900.—Moderate thunder rain.

Time.		Fall.	Character.	Rate of Fall.	
hrs.	min.	inches.		inches per hour.	
0	5	·04	*e*	·480	
0	3½	·03	*e*	·513	·633
0	1½	·02	*e*	·800	(18 min.)
0	2½	·01	*d*	·240	
0	2½	·04	*f*	·960	·445
0	3	·05	*f*	1·000	(35 min.)
0	2	·01	*d e*	·300	
0	15	·06	*d e*	·240	·280
0	14	·03	*d*	·128	(1 hr. 45 min.)
0	46	·17	*d e v*	·221	
0	7	·02	*d*	·171	
0	3	·01	*d*	·200	
0	15	·01	*b c*	·040	
2	0	·50		·250	

(9) July 16, 1899.—Thunder rain.

Time.		Fall.	Character.	Rate of Fall.		
hrs.	min.	inches.		inches per hour.		
0	1½	·05	*f*	2·000	1·313 (10½ min.)	·730 (20½ min.)
0	1¼	·05	*f ex*	2·400		
0	4	·10	*f*	1·500		
0	3¾	·03	*e*	·480		
0	5½	·01	*d*	·109		
0	4½	·01	*d*	·133		
0	30	·01	*b c*	·020		
0	50½	·26		·308		

(10) July 16, 1900.—Thunder rain.

Time.		Fall.	Character.	Rate of Fall.		
hrs.	min.	inches.		inches per hour.		
0	6½	·02	*a b c d e v*	·184		
0	2¼	·02	*e*	·533		
0	3¾	·01	*c d v*	·160		
0	3½	·04	*e*	·684		
0	3	·04	..	·800		
0	1	·05	*f ex*	3·000	·19 in. in 4½ min. = 2·533 in. per hour	·26 in. in 8¾ min. = 1·782 in. per hour.
0	1	·06	..	3·600		
0	1¼	·05	..	2·400		
0	1¼	·03	*e f*	1·440		
0	2	·02	*e*	·600		
0	0¾	·02	*f*	1·600		
0	1	·02	*f*	1·200		
0	0½	·01	*f*	1·200		
0	27¾	·39		·843		

The above are all ordinary falls of their several characters.

After careful consideration of the subject the Author suggests that the figure values assigned in the following table may be accepted as giving a considerable approximation to accuracy:

Very slight rain	*a*	below ·02
Gentle rain	*b*	·02 to ·05
Moderate rain	*c*	·05 to ·10
Steady rain	*d*	·10 to ·25
Heavy rain	*e*	·25 to ·80
Very heavy rain	*f*	·80 to 2·00
Exceptional fall	*ex*	above 2·00

From records collected and published in 'British Rainfall' by the late Mr. Geo. J. Symons, to whose memory and valued labours the writer may be permitted to pay passing tribute, the following examples of extraordinary rainfall are quoted :—

Date.	Place.	Time.		Fall.	Rate per hour.
		hrs.	min.	inches.	inches.
June 23, 1878 ..	London	0	10	1·00	6·00
July 22, 1880 ..	Cowbridge	0	30	2·90	5·80
„ 13, 1889 ..	Henley-in-Arden	1	5	3·64	3·36
„ 16, 1892 ..	Flax Bouston	2	0	3·75	1·87
June 27, 1895 ..	Middleton-in-the-Wolds ..	0	30	2·00	4·00
„ 26, 1895 ..	Worcester	1	0	2·75	2·75
„ 27, 1895 ..	Scot's Gap	3	30	3·25	·92
Sept. 7, 1898 ..	Angerton	3	0	6·70	2·23
Nov. 2, 1898 ..	Pontypridd	2	0	2·24	1·12
„ 1 and 2, 1898	Ambleside	21	0	6·14	·29

The fall of 6·70 inches in three hours, noted at Angerton, Northumberland, on September 7, 1898, stands out as the most remarkable instance of extraordinary rainfall recorded in this country, especially as the storm was not confined to a small area but was experienced with modifications throughout a considerable expanse of country surrounding the principal centre of disturbance; and while the mean rate of 2·23 inches per hour was high, being about that which may be expected to occur at the height of an ordinary heavy thunder "spate," it is certain that at times during the storm the mean rate would be greatly exceeded. This fall was about 18 per cent. of the total amount recorded in that year at Angerton.

The Author has frequently noted, during thunderstorms, rates up to 2·40 inches per hour. The greatest rate he has observed was 3·60 inches per hour.

In 'British Rainfall' is also given the following table of frequent, noteworthy, and exceptional rainfall:—

Time.		Frequent.		Noteworthy.		Exceptional.	
—		Amount.	Rate.	Amount.	Rate.	Amount.	Rate.
hrs.	min.	inches.	in. per hour.	inches.	in. per hour.	inches.	in. per hour.
0	15	·33	1·33	·34 to ·75	1·36 to 3·00	above ·75	above 3·00
0	30	·50	1·00	·51 to 1·25	1·02 to 2·50	„ 1·25	„ 2·50
0	45	·65	·86	·66 to 1·60	·88 to 2·13	„ 1·60	„ 2·13
1	0	·75	·75	·76 to 1·75	·76 to 1·75	„ 1·75	„ 1·75
2	0	1·00	·50	1·01 to 2·00	·50 to 1·00	„ 2·00	„ 1·00

The discussion of the proper proportion of rainfall for which provision should be made in the design of sewerage or drainage schemes is beyond the scope of this paper. The varying influences of local circumstances and conditions, of the porosity of the soil and extent of paved and imperviously covered surfaces, of the length of sewers and velocity of flow obtainable in them, render the application of any general principle necessarily subservient to the judgment of the engineer in each individual case; but it appears that the probable amount of rain, as falling on the ground, should not be estimated in this country at less than one inch to one and a half inches in depth per hour, while the possible contingency of rain falling continuously during periods of several hours at higher rates, up to two and even two and a half inches per hour, should always be considered.

If the information contained herein should prove of either interest or assistance to engineers engaged in the construction of works of drainage, or if it should stimulate further investigations as to the actual rates at which rain is deposited, and so correct the misleading results accruing from the ordinary method of analysing rainfall records, the objects of this paper will have been achieved.

DISCUSSION.

Mr. E. G. Mawbey: I should like to propose a vote of thanks to Mr. Dalton for his paper. I quite agree with him in his conclusion that an inch to an inch and a half of rainfall per

hour should be provided for in the sewers; though I do not say that the sewers should be capable of carrying off that quantity. My predecessor at Leicester, Mr. Gordon, proved that only one-half of the rain found its way to the sewers during the time it fell, and I have since made experiments which go to confirm the same conclusion. I have an automatic indicator made by the Glenfield Iron Company, which indicates the rise of water in the sewer, and registers the flow and the quantity of the discharge. That also bears out the data which I have already given you. You may take it roughly that you ought to calculate for the storm and foul water sewers each to carry off a volume equal to a quarter of an inch of rainfall per hour, and if only half reached the sewers, then that really provides for an inch of rain per hour. It is no use attempting to design sewers to carry off an exceptional flow, for we have records of an inch of rain falling in twenty-four minutes. We have Casella's automatic rain gauge in use in Leicester, and we have very valuable results registered by it. We have got the returns compiled for the whole of the period I have been in Leicester, and during most of Mr. Gordon's time, and they are exceedingly valuable. We have also a cheaper automatic gauge by Negretti and Zambra, which we are putting down in several parts of the town. I think it is important for the larger towns to get these automatic rain gauges and have them fixed about half a mile apart.

Mr. W. Nisbet Blair: In seconding the vote of thanks to Mr. Dalton, it seems to me that this is a subject which is undoubtedly very useful to all the Members of this Association, because we must at some time or other have to make provision for dealing with exceptional rainfalls. Although, as Mr. Mawbey has said, there is no obligation on the part of the local authority to have sewers sufficiently large to carry off the entire rainfall, there may be circumstances that render it desirable you should make exceptionally ample provision. Some years ago, when I was at Nottingham, we had a large watershed area which had no effective means of throwing off the water which fell over it. Originally there had been a brook, but as the land was built on every owner culverted the brook, in some places making the culvert 5 feet in diameter, in others only 18 inches. It was very irregular in form and its capacity for discharge very small indeed. It had been the experience for years that in case of

thunder rain the water accumulated in the sewers until reaching a certain point in the valley, when it blew off the manhole covers and flowed down the surface of the road. That occurred so frequently and with such serious results that it was decided to drain the district. The result was the construction of a tremendous culvert, over two miles long, the smallest portion of which was 6 feet 9 inches in diameter, and the largest 13 feet 6 inches by 9 feet 8 inches. In order to form an idea of the size of culvert which would be required I had a rain gauge fixed in my office, and sitting there watching the rain falling, could tell from minute to minute how fast it was falling, and knew exactly when to go out to observe the water flooding the valley. That rain gauge was a most useful thing for special observations of that nature. The late Mr. Tarbottom recorded the rainfall of the district in great detail for many years, and in a report dated 1881 we have a record of some exceptional rainfalls. On three occasions in 1878 we have records of very heavy falls, for instance ·762 in twenty minutes, or at the rate of 2·286 inches per hour; on another occasion ·636 in forty minutes; and on the third occasion ·864 inch in an hour and a half, or ·574 per hour. Then in 1880 we have a fall of ·700 inch in thirty minutes, or at the rate of 1·400 inch per hour; and ·190 in twelve minutes, or at the rate of ·950 inch per hour. Those are enormous rainfalls. We found from observations in other watersheds of the borough that, taking the total rainfall within a definite period and gauging the total outflow from the sewer draining that watershed, we could ascertain the amount of rainfall to be removed during the time the rain fell. This is the most important point to bear in mind, that the rain falling on roofs and backyards has to get into the subsidiary sewers, and after that into the main sewers, so the discharge of rain is spread over a longer period than the rain takes to fall. We found from these observations that in one case 29 per cent. of the total quantity of rain flowed from the main sewer of that neighbourhood in the time the rain fell—that is, roughly one-third of the rainfall. On another occasion we measured almost the same proportion. We therefore decided that in the valley which was to be drained we must provide for removing one-third of the total rainfall during the period of the fall. That I believe has been ample provision. I think Mr. Mawbey suggested one-half; but of course a great deal

depends upon the gradients of the branch streets. In those valleys we had gradients of 1 in 10, so that you may realise the velocity in the sewers was enormous. Since that culvert was constructed it has run about two-thirds full, something like a discharge of about 40,000 cubic feet per minute. It is a river in itself. Imagine that water going down the street surfaces. Before the construction of the culvert it had frequently flooded the district, and the water had actually washed houses down by its weight. In a case of that kind it does become a question for the local authority to say we will not allow this wreckage of property to continue in our district and we will make provision to prevent it at the expense of the rates. The population of 25,000 in this district, almost a town in itself, were unanimous in demanding that the provision should be made by the local authority. These figures given us by the author of the paper go to form a certain amount of ascertained facts to assist all who are interested in forming a conclusion upon a sound basis. I do not agree with the Author as to one sentence—that the discussion of the proper proportion of rainfall for which provision should be made is beyond the scope of the paper. I think that is exactly where the scope of the paper becomes useful, and I hope, having taken up the question, he will continue his observations to that practical end, more particularly as to the rate at which the rainfall is given off by main sewers, and give us generally the gradients and character of the locality.

Mr. J. P. Dalton: Mr. Mawbey's records of the rainfall in Leicester, extending as they do over such a long period, will be very valuable when tabulated. A few such records of automatic gauges taken at different places for two or three years, and showing the percentage of rain falling at various rates, would, I think, be found to be generally applicable to the greater part of the country, as, I am of opinion, variations in the yearly amount of rainfall are due more to differences in the length of time during which the rain continues than to differences in the percentages at various rates. As to the scope of the paper, I did not mean the paragraph referred to by Mr. Blair to limit the discussion by the Members on the paper, but, as I have had no opportunities of making observations of the discharge of sewers as compared with the rainfall, I could not touch that branch of the subject.

THE LAST TWELVE MONTHS' EXPERIENCE IN THE BACTERIAL TREATMENT OF SEWAGE.

By GEORGE THUDICHUM, F.C.S., Etc.

In reviewing advances that have been made during the past year in the various methods employed for the bacterial purification of sewage, the observer will be at once struck by the fact that such improvements or alterations relate entirely to matters of detail and not to new modes of applying the principles laid down some years ago. No startling innovation such as the Sutton coarse-grain bacteria bed or the septic tank has been brought forward; and the fine-grain bed, whether worked intermittently by alternate filling and emptying, or by the intermittently-continuous method, still stands as the acknowledged best means of final purification, as described by the present Author in a paper read before the Society of Engineers in December 1896. There have, however, been very many novelties introduced in the way of automatic arrangements for controlling the filling and emptying or the distribution over the surface of filter beds, and some of these it is proposed to discuss in the present paper.

The much-argued question, as to whether the preliminary breaking up of solids and preparation for final oxidation is necessarily anaërobic, has not yet been settled. It is contended by some that such primary simplification of complex bodies and solutionising of solid matters can only take place in the absence of air, and that a coarse-grain Sutton bacteria bed is only a septic tank in which the anaërobic organisms are employed in the most disadvantageous manner possible. But the investigations of Dr. Clowes at Crossness, on a 13-foot coke bed, prove conclusively that (1) aërobic organisms are at work, since the proportion of oxygen in the air contained in the beds is gradually reduced whilst the beds stand empty; and (2) anaërobic con-

ditions are never produced since such reduction has not been found to exceed 25 per cent. of the original amount. From this it appears clear that whilst the bed is empty, which, if it be worked under the requirements of the Local Government Board, will be some eighteen hours out of each twenty-four, the action upon the organic matter retained in it must be purely aërobic. Again, the crude sewage enters such a bed when the latter is fully charged with air and the aërobic organisms are in fullest activity; the time during which the bed is submerged is insufficient to bring about a preponderance of anaërobes; and the effluent from the coarse-grain beds, in the case of Sutton itself, has frequently reached the nitrifying stage.

It therefore appears to the Author that—quite apart from any question of the desirability of employing one or the other of the two methods—the preliminary liquefaction can be satisfactorily accomplished by either; and in the case of the coarse-grain bacteria bed the action is aërobic in the main, helped to a small extent by anaërobes, whilst in the septic tank it is plainly chiefly anaërobic, although a certain amount of work is effected by aërobes.

The Author is aware that this view is in conflict with those of many observers; but the fact remains that the Sutton bacteria bed does digest and solutionise the solid organic matter, and, having in mind what has been said above, it is difficult to look upon the action of such a bed as anaërobic. In further proof of the possibility of purifying sewage matters without the intervention of any septic process, reference may be made to experiments by Dr. Dupré, which have been alluded to by the Author elsewhere, and are quoted again by Rideal in his recently published work on sewage purification. Dupré found that if crude London sewage were mixed with thirty volumes of fully aërated water, no fouling took place, and the organic matter was finally oxidised without any preliminary putrefaction. Oxygen was still dissolved in the water at the close of the experiment and the process in this case must have necessarily been wholly aërobic.

In practice, however, the use of a tank or receptacle of considerable relative size, placed between the sewer and the first set of bacteria beds, has much to recommend it. In the first place, the nature of the inflowing sewage can be to some extent equalised; that is to say, a smoothing influence is exerted and

the sewage leaving the tank is of a more average character, and does not exhibit such sudden changes as may be frequently observed in cases in which manufacturing effluents are discharged into the sewers. This is of itself very important. Secondly, extreme variations in the rate of flow can also be to a considerable extent controlled, thereby giving greater power of dealing with sudden rushes. Thirdly, no screening is required. In the case of a coarse-grain bacteria bed the coarse particles of suspended solids must be either so broken up that they will enter the interstices of the bed and not be retained on its surface, or they must be removed by straining. This latter operation is not very satisfactory, and the matter collected upon the screens is of a most disagreeable and offensive nature, and, unless dealt with by burial or otherwise, at very frequent intervals, may easily cause a nuisance. In the recent experiments made on London sewage by Dr. Clowes, the chemist to the London County Council, it was found that when crude sewage was employed the coke became coated with fragments of chaff and straw, probably derived mainly from horse-dung and with woody fibre from the wearing of wood pavement in the streets. Paper in a finely divided state also shows a tendency to stick and necessitate stirring of the surface. For all these reasons a preliminary tank treatment is desirable, and further, it is not necessary that such tank should be covered, since air and light are sufficiently excluded naturally to enable the anaërobic organisms to perform their functions. The report by the experts employed to enquire into the question of the treatment of the sewage at Manchester, dated October 1899, shows clearly that there is practically no difference between the effluent from a closed and that from an open tank; and the Author's own experience confirms this. The possibility of nuisance arising from an open tank is, however, another question, which can only be solved by time and actual experience. The Author's acquaintance with the odours evolved from sludge settling tanks on a large scale would lead him to the belief that open septic tanks might not always be free from suspicion of nuisance. Dr. Kinnicutt, of Worcester, Mass., U.S.A., in a paper read in January of the present year before the Boston Society of Civil Engineers, expresses a different opinion:—"In all these places" (i.e. Accrington, Huddersfield, Leeds and Manchester) "the general appearance of the liquid in the tank was the same, very dark

and opaque, the surface coated over with a thick layer of solid matter, and the activity of the action in the tank shown by the thousands of bubbles of gas escaping through this layer of solid matter. The effluent was of a dark brown colour, containing suspended matter in a very fine state of subdivision, but neither the odour given off from the tank nor from the effluent was so offensive as to prevent its use by towns or cities." A strong argument in favour of covering the tank is undoubtedly that by so doing it may be rendered possible to make a profitable use of the evolved gases. At the Belleisle works, Exeter, the gas produced in the septic tank is employed for lighting purposes, and there can be no doubt that with further experience and improved appliances, a result of considerable economic value will be obtained.

Of improvements in mechanical means of filling and emptying bacteria beds, one of the most important is that recently introduced by Messrs. Cameron, Commin and Martin. In the septic system, as originally worked, the time occupied in filling a bed was dependent absolutely upon the rate of flow of the sewage in the sewer; and since the discharge of effluent from one bed was also dependent upon the filling to the necessary height of another, the beds were frequently too long filled, partially or entirely, with water, and no regular working periods could be enforced. By the new gear, however, a bed can be made to stand full for any required time before discharge; and between fillings the sewage is headed back in the tank, so that when the inlet valve to a bed is opened, the tank effluent escapes with great rapidity and speedily fills the bed. A full description of the mechanism by which these various actions are controlled would be too long for this paper, but the effects upon the working of the beds may be briefly considered. In the first place, instead of the filling of a bed occupying a period of time proportionate to the rate of flow of the sewage, such filling can be accomplished at any desired speed up to a given maximum, thus ensuring the first condition of highest efficacy upon which the Author has alway insisted, viz. that the bed should be filled as quickly as possible. Secondly, the period of standing full is regulated in the bed itself, being independent of other beds, and the actual time of contact with the organism on the bed material can be perfectly controlled. Thirdly, the discharge from a bed can be regulated, so that,

instead of the bulk emptying in a few minutes, as is the case in the Belleisle installation, the whole can be discharged gradually. These alterations are all of the utmost importance as removing practical difficulties in the way of working bacteria beds to the greatest advantage from the theoretical point of view.

There have been many alterations proposed in the method of application of sewage or septic tank effluents to bacterial filters, but whether these can be classed as "advances" remains to be proved by time. They are mainly directed to perfecting means of working by constant, or intermittently constant flow, and include various kinds of automatic sprinklers or distributors. The Author has recently had an opportunity of examining a Whitaker-Bryant installation, in which the sewage, after passage through an open septic tank containing about twenty-four hours' flow, is sprayed on to a bed of coarse coke by means of a patent automatic sprinkler, the septic tank effluent being lifted by a pulsometer pump and warmed by the exhaust steam. The results obtained are very satisfactory, except that the filter effluent contains some amount of black suspended matter, which however, is readily separable by deposition, the resulting final effluent being in all respects good. Other distributors, such as the Candy-Caink, are said to work very well, but the Author has had no opportunity of making personal inspection.

Of sewage works opened during the past year attention should be specially drawn to those at Hampton-on-Thames. Owing to various local circumstances an exceptionally good effluent was demanded here, and, acting on the advice of Mr. Dibdin and the Author, the method of treatment adopted was three purifications by aërobic beds. The effluent produced is of the highest quality; but, in accordance with regulations, it has to be passed through land after leaving the third set of beds, with the result that the organic matter which it contains in solution is practically doubled.

The Author's object in writing this little paper is rather to learn than to teach, and he trusts that many Members of this Association who have recently given their attention to the sewage problem, will in the course of discussion give new experiences to the meeting.

DISCUSSION.

Mr. E. G. Mawbey: I should like to propose a vote of thanks to Mr. Thudichum for this paper. Mr. Dibdin and Mr. Thudichum have given very great thought and labour to the consideration of this question, and we very greatly value their experiences. We have been carrying on very extensive experiments in Leicester, and the results of those experiments have been embodied in a report of which several of our Members have had copies, but unfortunately I have not been able to comply with the number of applications received for them. We found out from our experiments a number of valuable things. First of all, that it would not be possible to clarify our sewage without making sludge. We tried altogether about seventeen different processes. Our position in Leicester was this. We have a sewage farm of 1700 acres in extent, of which 1300 or 1400 acres is available for sewaging. It is clay land—heavy clay land. The difficulty we had was that there was only about 6 inches of good soil, and we could not get sufficient filtration before the sewage reached the effluent drains. My predecessor, Mr. Gordon, was dead against this scheme. It was forced upon him because it was the only land in one piece which was available for the sewage of Leicester. Mr. Gordon got out the first contracts, but it fell to my lot to lay out the whole of the land, and to design the underdrainage. Sir Robert Rawlinson said, Don't drain clay land or you will ruin it for purification purposes; others said, You must drain it or the land will be of no use for taking sewage. We proceeded to make numerous experiments with the land. It was a regular thing after sewage had been put on the land for it to be ten or twelve weeks before we could again go on the undrained land with horses, and I have known it to be as long as twenty-one weeks. So it became a problem as to what we were to do with it. If we did not drain it, we could not work it; if we did drain it, some said it would be a failure. Fortunately for me, the land fell very rapidly to one valley one way, and very rapidly to the other valley in the other direction. The conclusion I arrived at was to take advantage of that fall, and drain each field separately. I laid the main drain along the bottom of the field, and brought it to the lowest corner, connected my tributary drains to it, and then, at a flatter gradient, brought out the main drain on to the surface

of the next field below. We dealt with it as a great agricultural farm. We turned the dykes into effluent drains. On the outfall of each mainland drain we put in a chamber fitted with two valves, by which we carried the sewage effluent either on to the next field or into the effluent dyke; and the result of this arrangement was, that we could treat the effluent over and over again until we had succeeded in purifying it. Now, as to this question of bacterial treatment, our position may be similar to a number of other towns. We have over 40,000 more people to provide for than we had when we started the farm, consequently we have to clarify the sewage or to double the area of the land, or to drop the land and go into the bacterial treatment alone. I never tried to put the raw sewage on to the bacterial beds. I put the sewage through the settling tank first, and then on to the grass to finish it off. That was the first process. We found we made a lot of sludge that way, and we fouled the grass because we did not get sufficient clarification. Then we ran the sewage from the tanks through a coarse bacteria bed on the intermittent system, three fillings a day, and then put it on to the grass. That experiment gave us a very admirable result, but we made a lot of sludge in the detritus and settling tank. Then we dropped the settling tank and sent it straight from the detritus tank on to the grass with a perfect result. Then we tried a septic tank; we made a large tank air-tight and trapped the outlets and inlets. We expected then we should not make so much sludge. We had been making nine or ten tons of sludge per million gallons of sewage. But we found we were making about the same sludge in the septic tank, and in the detritus tank. Another thing we found was that, after it had gone through the detritus tank and septic tank and coarse bed, the effluent was not so good as when we did not use the septic tank at all. Therefore, we came to the conclusion that to adopt the septic tank as well as the bacteria beds would be a very extravagant method of clarification. Another experiment we made was to send the sewage through the detritus tank and the septic tank and then on to the land. We fouled the grass and the farm. What we found as the result of all our experiments was this—that the very best way to clarify the sewage—the sewage of Leicester at any rate—was to send it through a detritus tank, then through a coarse grain bacteria bed on the intermittent system, and then finish it off on the old pasture

or ryegrass. We tried the bacteria system alone, through a detritus tank and through two contact beds, but the results were not so good as when we passed it through a detritus tank and a coarse bed, and finished it off on the grass land. Then we tried triple contact beds, and we found we obtained about the same results as with the one contact bed and the grass. We designed works at a cost of 168,000*l.* Our Council adopted this scheme for clarifying the sewage before passing it on to the land. My experience is that we have proved where you cannot get land you can clarify the sewage without it, but where you have got land and enjoy a certain amount of success, it would be very unwise to throw away that land and start afresh, with a considerable risk as to the results. I have briefly given you the results of the Leicester experiments, though I am sorry to say I am not in a position to supply you all with a copy of the report, but if any Member wants any further information I shall be pleased to send it.

Mr. MacBrair: We have a combination of sewage disposal works which can only be seen at Lincoln. Ours is a very strong sewage, and we have only a very small farm upon which to put it. We have the ordinary settling tanks, and some years since we put down 2000 yards of polarite beds. This not dealing effectually with the sewage, we laid down some coarse bacteria beds at the top of the farm, but from the position of the beds the sewage had to be delivered to the beds crude, because it could not be passed through settling tanks. The result of this treatment was not good, as the sewage was too strong, so we began something else. Triple contact beds were tried, and at the present time are in operation. During the last few months we have allowed the crude untreated sewage to settle in the ordinary tanks all night. At about three or four o'clock in the morning the contents of the settling tanks are run on to the coarse bacteria beds, so by six o'clock we have 1½ to 2 tanks ready for the daily sewage. I find my best results are obtained in this way, i.e. twelve hours' settlement and double contact. That gives me better results than anything else, even than triple contact without settlement. I have thereby reduced my chemical bill by two-thirds. What I cannot put on the contact beds, I put on the polarite beds, and the remainder goes on the farm, which really takes the position of "residuary legatee." To sum up, I find the best results are

obtained from double contact beds after the crude sewage has been standing in settling tanks for 12 hours.

Mr. C. C. Smith: As the Author remarks in his paper, there has really little new occurred during the past twelve months in the development of the bacterial system of sewage treatment. So far as we at Sutton are concerned we are unable to chronicle any marked advance, and I attended this meeting more in the hope of learning something of the experience of others than to relate anything myself which can be of added interest.

The results which are obtained at the Sutton sewage works continue to be satisfactory. At the present time considerable additions are being made so as to enable the whole of the sewage to be treated by bacteria filters, and I hope to have these completed within about two months' time.

It will probably be remembered that the screening of the crude sewage was originally advocated prior to its being passed on to the coarse grain beds. I have, however, found that by the adoption of the detritus tank—trapping the inlet and outlet—the need of a screen, which is to prevent the deposit of paper on the surface of the bed (which limits proper aëration), is obviated.

It has been alleged from time to time that the same results could be obtained in a detritus tank the inlet and outlet of which were untrapped as in one where such trapping was constructed. In order to test this I adapted two of the old chemical precipitation tanks, having a joint capacity of 100,000 gallons, for the purpose, and passed some 300,000 gallons of crude sewage per day through them. What were the results? After running them for three weeks as ordinary untrapped tanks no scum accumulated, because the current swept it forward to the outlet, and, as is usual in ordinary tanks, the sludge accumulated on the floors—to a depth of 18 inches. Having satisfied myself that this process if continued meant a removal of the sludge difficulty, I then proceeded to have the inlet and outlet trapped, when it is interesting to note that a scum began immediately to form, and on the formation of a complete covering, the sludge on the floors of the tank decreased and went into solution, and now, instead of 18 inches which existed at the time of the alteration, I have, after working them on this principle for 18 months, only 3 inches of deposit on the floor.

Just as the sewage of different districts varies in character

so will, in my opinion, the capacity of detritus tanks have to be varied to meet the varying conditions. Those used by me have a capacity equal to two hours of our maximum flow. The sewage at Sutton is purely domestic, though as shown by analyses a fairly strong one. With regard to the question as to the best material to be used—for coarse-grain clay ballast, such as we have used for economic reasons, is not to be generally recommended as it has a tendency to resolve itself into its original condition of clay, when aëration is of course under such conditions impracticable—I have, however, found that, if burnt ballast has to be used at all, if it be placed in the lower part of the filter where it cannot be so readily acted upon by the atmosphere, and the surface to a depth of one or two feet be covered with a harder material, say clinker from gas-works, that the proper aëration of the bed can be maintained for an indefinite period, and the turning over of the surface may be largely obviated.

The advantage to be gained from the use of clinker is that each piece has a large rough surface, which favours the development of bacteria and it is practically indestructible.

Various materials may, however, be used for coarse grain beds. I have been working some experimental filters for a period of eighteen months, constructed of (1) granite broken to a 2-inch gauge; (2) broken crockery ware and glass; (3) scrap-iron and corroded tins from the house refuse; (4) chalk; and (5) blue roofing-slate, to test their adaptability for use in such beds. The three former gave very satisfactory results, whilst the two latter were not so satisfactory. These experiments show that a local authority may adopt materials obtained locally, and I have not the least doubt that in a district where millstone grit or sandstone is readily accessible, excellent coarse grain beds may be made with such material.

There is the question of the application of the sewage to the beds or filters, as they are popularly though erroneously termed. In my experience I have been unable to find such efficiency obtainable from sewage sprinkled on the filters, as when the sewage is applied intermittently. One has to provide against the action of frost with the use of sprinklers, which is not the case when the sewage is flooded. In the latter case, the temperature of the sewage is above that of the atmosphere, and the frost is unable to affect it before it disappears in the

bed, the temperature of which is again higher than that of the external air. With a sprinkler, however, the sewage is broken up into a fine state, in which condition its temperature is quickly lowered, and as a consequence it is liable to be frozen and the bed put out of work as I have found on numerous occasions with a bed so worked under my supervision.

One word in reference to automatic apparatus. There is no doubt that in many cases a considerable economy can be effected in labour by the use of one of these. I need only mention three, viz. (1) Adam's automatic syphons; (2) the Septic Tank Company's automatic apparatus; and (3) Ridgway's apparatus, made by Messrs. Mather and Platt. Each one of these is good, and by their use the beds may safely be left to work automatically for a week at a time.

Finally, I would refer to the requirements of the Local Government Board. These do not err on the side of insufficiency. My Authority did not feel justified in spending the large sums of money which would be necessary to comply with these requirements under the conditions existing at our works. We are consequently carrying out the extensions, partly out of revenue and in part borrowing money under Section 235 of the Act of 1875, by mortgaging the land purchased for purposes of sewage disposal, which can be done independently of the Board.

Mr. YORK: I should like to ask one question relative to the Hampton-on-Thames works. I notice that Mr. Thudichum says that the effluent produced by the three beds is of the highest quality. But in accordance with regulations it has to be passed through land after leaving the third set of beds, with the result that the organic matter which it contains in solution is practically doubled. Is the organic matter of which Mr. Thudichum speaks, artificially placed on the land, or is it dissolved from the land? I should like an explanation of that, as I cannot see how the organic matter in the effluent can be increased by passing it over the land. My own experience as to bacteria beds is quite in the earliest stages, and I may say differs entirely from any description which has been given to-day. Owing to certain engineering and physical difficulties, we could not get the bacteria beds near our outfall; it had to be put on the bottom part of the farm, with the result that the sewage has to pass first over the land, and then over five

bacteria beds. The matter has been the subject of inquiry by the Local Government Board, and we are awaiting the result with some anxiety. We have great difficulty in meeting the requirements of the different Authorities, because the stream which receives the effluent is dried up for the greater part of the summer, and is therefore all effluent.

Mr. E. G. Mawbey: We found the average of all the effluents we produced at Leicester was this—after passing through the number one contact-bed ·36 grains albuminoid ammonia, and when passed over the land ·16 grains albuminoid ammonia. If you passed sewage through three contact-beds, and then sent it through land which was not in good condition, it might possibly happen that it would come out in a worse condition than it went in; but it should not be accepted from this as a broad principle, that the passing of sewage effluent from bacteria beds on to land was going to make it worse.

Mr. Dennis: My Authority had a letter recently from the Local Government Board requiring them to put the effluent from the secondary filters on to the land, and the result has been that the final effluent has been made worse. It is one of the points which I cannot understand, why the Local Government Board, when we get such an excellent result from the second filter, should compel us to pass the effluent over the land and pollute it. We are at present treating 300,000 gallons of sewage a day on the bacteria system, and during this year we shall have sufficient filters to treat the whole of the sewage. We pass the sewage from the pumping well, from which it is raised 12 feet to an intercepting or detritus chamber, 25 feet by 8 feet, where we intercept the mineral matter which comes down the sewer. From that tank it passes along a carrier without any other treatment whatever on to the primary beds. Our primary beds are constructed with brick walls and concrete bottoms. I may say that at another place in our immediate neighbourhood where they have adopted a similar system, they have constructed the secondary beds with an earth embankment, and the clinker filling is supported upon a clay bottom, and in their case the effluent is not entirely satisfactory. It has occurred to me that their effluent may be polluted by the earth embankment and the clay bottom becoming "sewage sick" after being brought in contact so many times with sewage and without proper means being adopted to aërate the soil. The

ALDERSHOT SEWAGE.—Grains per Gallon.

Date.	Raw Sewage.									Primary Beds.						Secondary Beds.					
	Total Solids in Suspension.	Mineral Matter in Suspension.	Organic and Volatile Matter.	Total Dissolved Solid Matter.	Chlorine as Chlorides.	Ammonia Free and Saline.	Albuminoid Ammonia.	Nitrogen as Nitrates and Nitrites.	Oxygen Absorbed by Organic Matter in 3 hours.	Total Dissolved Solid Matter.	Chlorine as Chlorides.	Ammonia Free and Saline.	Albuminoid Ammonia.	Nitrogen as Nitrates and Nitrites.	Oxygen absorbed by Organic Matter in 3 hours.	Total Dissolved Solid Matter.	Chlorine as Chlorides.	Ammonia Free and Saline.	Albuminoid Ammonia.	Nitrogen as Nitrates and Nitrites.	Oxygen Absorbed by Organic Matter in 3 hours.
June 22, 1898	..	..	..	..	..	..	..	..	..	58·1	8·3	3·31	·097	·245	·485	..	..	..	..	..	..
„ „	..	..	..	..	..	..	..	..	..	60·2	8·9	4·53	·099	·053	·583	..	..	..	..	..	..
Nov. 16, 1898	..	..	..	..	..	..	..	..	..	45·5	4·7	·196	·028	1·4	·150	..	..	..	..	..	..
June 12, 1899	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	64·0	6·0	1·75	·058	·14	·254
July 19, 1899	..	..	..	54·6	8·2	6·35	·260	..	1·22	47·6	7·4	1·52	·054	·63	·348	45·5	6·5	·098	·042	·86	·360
Sept. 12, „	50	15·8	35·2	115·5	9·2	8·14	·445	..	2·14	51·1	9·5	2·88	·088	·07	·402	50·4	7·2	·845	·044	1·26	·231
Dec. 11, „	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	52·5	5·4	·77	·025	1·4	·152
Feb. 8, 1900	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	49·0	5·3	·49	·04	1·4	·190
April 26, „	37·6	10·1	27·5	56·7	8·5	6·85	·481	..	1·617	38·5	5·3	2·64	·1	·028	·392	40·6	5·8	1·08	·058	·385	·248
July 6, „	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	42·7	5·6	1·00	·035	1·4	·357

method we adopt in filling our primary beds is, instead of filling entirely with coarse material, to fill the lower portion of the filter with clinker of sizes varying from 2 inches upwards, and the top 12 inches with small stuff that passes through a ⅜-inch sieve. With regard to the charging of the primary beds with sewage, we find an advantage in filling slightly above the level of the filtering material, as the wind carries and distributes the paper and other light floculent matter which would otherwise accumulate in front of the delivery. The top filling is brought in contact with the bed during the two hours that it takes to discharge it. We have obtained very excellent results from that mode of working. The secondary beds are of the same capacity as the primary beds, except that they are 18 inches deep instead of 4 feet 6 inches, thereby exposing a great area to atmospheric influences. The time of holding up varies from two hours to three and a half hours; but in the secondary beds it passes through and it takes five hours to complete this operation. The question of temperature has been mentioned by Mr. Chambers Smith. During last winter, as Members know, we had a rather heavy snowstorm and one or two severe frosts. On February 8, our analysis from the secondary beds was—total dissolved solid matter 49·0; chlorine as chlorides 5·3; ammonia free from saline ·49; albuminoid ammonia ·04; nitrogen as nitrates 1·4; and oxygen absorbed in three hours ·190 grains per gallon. The atmospheric temperature was 27 degrees; the temperature of the sewage 46 degrees; of the first filter 46 degrees; and of the second filter 41 degrees. On several days prior to that we had frost, and it had no effect whatever upon the proper working of the system. Again, we have experienced no difficulty whatever as to the filling up of these beds. On January 1 and June 10, tests were made as to the capacity of one of the primary beds, and they were practically the same, varying only between 27,500 gallons and 27,800 gallons. The sewage occupies something like 40 per cent. and the filtering material something like 60 per cent. of the primary beds. The District Council are so satisfied with the result that they intend to complete the system so as to deal with the whole of the sewage.

Mr. Campbell: Mr. Thudichum in his opening remarks stated that during the past year no startling innovation such as the Sutton coarse-grain bacteria bed or the septic tank has

been brought forward. This is quite true, but a larger amount of experimental work has been carried out at a number of sewage works, in all parts of the kingdom, both on a more extensive scale, and with more thorough investigation than formerly. A large number of corporations and other public bodies, when they heard the statements circulated regarding the capability of coarse bacteria beds for purifying sewage, whereby chemicals and the formation of sludge are dispensed with, thought that a solution to the sewage problem had at last been found. At a large number of sewage works beds have been constructed from a square yard to an acre in area, and the use of coarse bacteria beds as a means of purifying sewage practically demonstrated. If the results obtained at the various works where these beds have been given a fair trial, constant observations of the capacity being noted, could be gathered together and compared, they would form a very valuable report. At a number of works, however, these beds have proved a failure on account of the rapid decrease in capacity, and it would be very surprising if this did not occur, if one takes into consideration the amount of mineral suspended matter (not including sand, etc.) present in the sewage. Even with purely domestic sewage mineral matter must accumulate in the beds, as the suspended matter in sewage is never entirely organic, and also the mineral matter which accumulates in the beds must be accompanied by organic matter which will retain a large quantity of water. It was originally claimed that practically the whole of the sludge was rendered either soluble or gaseous by the bacteria in these beds. This proved otherwise, and devices such as the settling of the sewage so as to free it from as much suspended matter as possible, were resorted to; these led to the adoption of the open septic tank as a preliminary process. The beds can only be considered to form a part of this system, the important work, viz. the dissolving and gasifying of the suspended matter, which they were originally claimed to accomplish, now takes place in the open septic tank, but under different conditions, the beds oxidising only the soluble organic matter, and a trace of suspended matter. If the Whitaker-Bryant filter be used for the oxidation of the septic effluent, the process would be entirely biological, but upon different lines to the Sutton or Dibden system. I have given the system a fair trial at Huddersfield, the results of which will most likely be of

interest to you. Two beds were constructed, a coarse and a fine. The coarse bed was 40 feet by 40 feet by 3 feet 6 inches, consisting of clinker, the size of the pieces varying from ½ inch to 3 inches. The fine bed was 40 feet by 45 feet by 3 feet 3 inches, constructed as follows.

Top—	9 in. of clinker	.. ..	¼ in. to ⅝ in.
	1 ft. 11 in. „	.. ..	⅝ in. to about 1 in.
Bottom—	7 in. „	.. ..	1 in. to 2½ in.
	3 ft. 3 in. „	average depth.	

The sewage was well distributed over the surface of the beds in troughs. Both beds were well drained by land tiles. The sewage before running on the beds was thoroughly screened, first by a ½-inch screen and secondly by sheet zinc with $\frac{1}{16}$-inch perforations. The beds were never charged above twice a day, and were always given one complete day's rest per week.

Capacity of Coarse Bed.

August 9, 1898	.. .. ..	19,000 gallons (bed new).	
March 3, 1899	.. .. ..	9,000 „	loss, 52 per cent.
May 31, „	.. .. ..	7,300 „	„ 62 „
July 11, „	.. .. ..	6,100 „	„ 67 „
October 17, „	.. .. ..	5,600 „	„ 70 „
January 24, 1900	.. .. ..	4,800 „	„ 75 „

The purification effected by the beds continued satisfactory throughout the trial, almost the whole of the suspended matter was removed and a large quantity of the soluble organic matter was oxidised. The sewage drained freely from the coarse bed even when it had lost 75 per cent. of its original capacity. The average analysis of the sewage run on the bed for the latter twelve months of the trial was—

—	Ammonia.		Oxygen Absorbed.	
	Free.	Albuminoid.	3 Minutes.	4 Hours.
Raw sewage..	·80	·469	2·49	7·17
Coarse bed effluent	·40	·150	1·00	2·53
Fine „ „	·22	·094	·50	1·50
Percentage of reduction	72	80	80	79

When the material of the coarse bed was dug out, it was found that the interstices within a foot from the bottom were entirely filled with a dark spongy substance, above that height they were only partially filled. This dark spongy substance had a not unpleasant earthy smell, and contained a large number of various low forms of animal life, especially worms.

When dried it consisted of

53·7 per cent. mineral matter.
36·3 „ organic „

Samples of it were placed in closed bottles, in an incubator, and kept at 80° F. for several weeks. When taken out very little alteration had taken place, the samples still having an earthy smell.

Mr. J. S. Pickering: I quite agree that the improvements in the last twelve months have been in details rather than in the principle of the bacteria system. I have listened with great interest to Mr. Campbell, because my experience is directly opposite to his, and with sewage almost exactly similar to Huddersfield. The Huddersfield sewage is largely composed of trade refuse, and in Nuneaton we have similar trade refuse, from wool-scouring, dye-works, etc. From the chemical point of view one may judge of the nature of it by a comparison with other crude sewage. It often contains 2·0 parts per 100,000 parts albuminoid ammonia, as against 0·49 parts spoken of by another speaker, or four times the quantity of what has been described as a strong sewage. My experiments at Nuneaton have extended over two years, and we are so satisfied with the results that we are about to launch out on a large scheme for dealing with manufacturing refuse on the bacteria system. We have treated between 200,000 and 300,000 gallons of sewage per day on that system for over two years, and so far we have obtained excellent results. I cannot possibly understand Mr. Campbell's coarse-grain filters blocking up in the way he says they are doing. I have gauged by meter the flow from both the fine and the coarse-grain beds, and there is practically no diminution of the flow for that time in the fine beds, while the coarse-grain beds have silted up only to the extent of 33 per cent. Of course the silting up may go on, but I cannot imagine it continuing to the extent Mr. Campbell speaks of. Mr. Dennis referred to the undesirability of putting these bacteria beds

in the soil without brick walls. We have an acre of beds so constructed, and the results are satisfactory. Where the ground is strong, I do not see the necessity for putting down brick walls for the sides. We have given some attention to the septic tank, and have a tank holding 250,000 gallons, but I am inclined to think that sewage of the nature we have cannot be treated in a septic tank without some nuisance. The effluent from the tank is most offensive. That is not so from the coarse-grain bacteria bed; there is little or no offensive smell in connection with that. We are satisfied that the septic tank would not answer for our sewage, but that coarse and fine-grain bacteria beds will. I quite agree as to the necessity of silt tanks. I should say that is the weak point of Mr. Campbell's scheme. He has probably not sufficient silt tanks. Mr. Mawbey spoke of having 20 tons of sludge per million gallons. That shows how one ought to treat the sewage of each town on its own merits. We have nearly 100 tons of sludge per million gallons.

Mr. Mawbey: We have got from forty-four to fifty grains per gallon; I said that was the amount of sludge we had with the septic tanks, not the whole amount of sludge.

Mr. Pickering: You cannot lay down a tank for a manufacturing town and say it shall be the same size as for a purely residential town. Mr. Chambers Smith has given us some very useful information as to the materials to be used for these beds. When the subject was first brought into prominence a few years ago, it was stated that nothing would do but coke. But our experience has now proved that it is not so much the material as the degree of coarseness, and good results may be obtained from a variety of materials, so that one is not justified in going to considerable expense for a particular material. You can get good results from granite as a primary and secondary process. I have undertaken some experiments with 200 yards of granite broken to $\frac{3}{16}$-inch gauge, and have obtained very good results. The consequence is, that in our new works we shall probably not use coke at all, as coke is now costing in the Midlands about 1*l.* a ton. I entirely disagree with Mr. Dennis as to filling the beds over the top of the filtering material. I cannot possibly see how the bacterial processes can come into force when the beds are so filled, and the only reason given is that it allows the wind to blow the pieces of paper off the top of

the bed—not to my mind a very good reason. I think it is misleading to put forward one analysis as the result of some particular system; I do not think isolated analyses are of any use whatever, and we ought to entirely disregard them. What we want is a series of analyses to be of any use. The Author in his paper speaks of an effluent which had gone through three contact-beds and through land, with the result that it was worse when it left the land than when it left the contact-beds. As Mr. Thudichum is a chemist, I take it that statement is the result of careful examination, and not of one, but of a series of trials. I admit that I cannot understand it, because with carefully prepared land you expect to improve the effluent. If it is true—and I think we are justified in saying it is from the Author's standing as a chemist—then this question of land treatment ought to be settled one way or the other, because corporations are being put to enormous expense in carrying out works to meet the requirements of the Local Government Board as to the provision of land.

Colonel Jones, *V.C.*: The careful preliminary experiments carried out for the Manchester Corporation came to very much the same results as the experiments of Mr. Mawbey; and the conclusion of the experts was, that there is no difference whatever between the covered septic tank and the ordinary open tank of deposition. I think that is the most important fact which has come out this year. Then I think after Mr. Mawbey's statement to-day the "no more sewage sludge" advertisements are put entirely out of court; we may put away catch-penny statements of that kind. We know "the poor ye have always with you," and sewage sludge you will always have with you. With a septic tank and a detritus tank you can accept this formula; you get from each million gallons of sewage 6 or 7 tons of sludge containing 90 per cent. of water You cannot expect, and if you do expect you will be disappointed, to get rid of sewage without trouble and without labour. And as regards the bacteria system you will find in the long run it is a case of management. The A B C people have been at it for thirty years, and what is there in their system but good cleanly management? These bacteria systems have got to be tested with all that comes down the sewer, and not with selected portions of it. But I think this fallacy of no more sewage sludge has been exploded by the Manchester expert and by

Mr. Mawbey, and should be noted as one of the great things in the year's advance. Then, again, Mr. Thudichum's statement as to the perfectly purified effluent and its fouling by land is a very simple matter. The land on which his experiment was tried may have been neglected and left full up of sewage, and anyone who put clean water upon such land would get an impure effluent. There is one point established, and that is the horrible nature of the effluent that comes from the septic tank. Mr. Mawbey, in his report to the Leicester Council, said it was evident that the septic effluent could not be treated on old pasture or ryegrass without causing a nuisance, and he proceeds, "it seems to me that in sewage treatment offensive putrefaction should be reduced to a minimum, and that the more the disintegration is done in the presence of air, and the less the retention or stagnation of sewage, the less will be the land required." There is not sufficient evidence to show that the liquefaction with the closed detritus tank exceeded that with the open one. It is certain, however, that, whether closed or open, the detritus tank in order to retain its efficiency should be frequently emptied. What I have been preaching for thirty years is that you have to be cleanly in sewage treatment, and these tanks to be cleanly should be frequently emptied. I very much expected in this paper to find a reference to Mr. Scott Moncrieff, who has been working up the theory of Biological Agency in Sewage treatment more than anybody else, and tried to arrive at what the microbes can and will do. I know he has been very carefully at work with Dr. Rideal as his analyst, but I have not heard the results of his experiments. I should have thought Mr. Thudichum would have been familiar with those experiments, and have referred to them in his paper.

Mr. Smith: The bacterial filters we have in use at Kettering are giving about 50 per cent. of purification, this is a rough average of a good many analyses. We expected at the time we put them down we should get a better result, but we do not get drinking water from them, and it is no good professing we do. As our works are not entirely new works, but old works extended and adapted to the system, it is satisfactory to hear that there is some sludge to be found in septic tanks, as in our works the sludge was dealt with by pressure, and this system has been continued. In extending our tank accommodation we

put down two tanks on the Dodmund principle, and they act very efficiently and at the same time effectually prevent any detritus reaching the filters. Our filters have a total area of 1½ acre, and are placed in the ground without any concrete or brick sides and bottoms; they are 4 feet deep, and are made of coke breeze, varying in size from an inch and a half downwards, all put in together, not in layers of different sized materials. The effluent from the filters has to go out to land in accordance with the Local Government Board practice, and I may say we get another 50 per cent. of purification of the effluent on the land. Our ordinary dry weather sewage flow is from 500,000 to 600,000 gallons per day.

Mr. G. William Lacey: The discussion has been one of the most interesting in the history of bacterial treatment of sewage. So far as Oswestry is concerned, the working of the bacterial system has been satisfactory. We have obtained a percentage of purification of our sewage of from 84 per cent. to 94 per cent. In addition to the bacteria beds, we have in use two settling tanks which formed the original works, and my experience with open inlets and outlets is the same as that of Mr. Chambers Smith. I cannot get any appreciable scum to rise to the surface, but I get 15 or 18 inches of sludge in about eight weeks. I have found that the capacity of the primary beds has reduced since the commencement by 25 per cent. to 30 per cent. and remains at that. The material of which the beds are formed is cinders riddled from old house refuse, and in the primary beds ranges from ⅜ inch to 1½ inch gauge. As may be supposed the greater proportion of this class of material is of a size from ⅜ inch to 1 inch, and I have come to the conclusion that if the material could have been obtained so as to have got a greater proportion of the larger gauge the reduction in capacity of the beds would have been less and the purification by them probably more. There is one point with respect to the length of time the liquid is kept in the beds. I have found by analysis that even when effluent remained in all night there was no practical difference between the quality of that and of effluent which had been liberated after two or three hours' contact.

(*Communicated.*)

Mr. T. Caink :—The importance and value of such a review of the progress made in a process such as that treated of by the author of this paper, lies to a great extent in indicating the direction towards which the various investigations point for the final solution of the problem.

It seems clear from the paper that there is a general agreement amongst experimenters with regard to the extreme ends of the process, difference of opinion being chiefly in the route to be taken between. I take it that Mr. Thudichum and Mr. Dibdin, while being prepared to demonstrate that sewage purification can be effected without the use of tanks for dealing with the solids, nevertheless agree with practically all others, that interception of the sewage in tanks for arresting detritus and for the mechanical disintegration of the solids into a state of fine subdivision, is at any rate desirable. There is also practical unanimity that the final oxidation of the liquid is purely an aërobic one, but in conducting us from the first to the last stage of the process there is considerable difference of opinion as to the route to be taken. Some, on leaving the detritus tank, plunge us into the region of aërobia, others lead us through the realms of anaërobia, while others seem to keep so near the border line between the two that it is disputed whether they are in one territory or the other. I have not had the opportunity myself of experimenting on any considerable scale. I happen to live in a city which at present possesses an extremely convenient method of disposing of its sewage. Old Father Severn has been good enough to swallow it all for the past forty years, and it is not without bearing on this subject to state that numerous doctors, who have from time to time examined him, declare that he has digested it perfectly, and is after all these years absolutely none the worse for it. I have, however, endeavoured to follow the investigations of others, and there appears to me constantly cropping up a series of converging lines, all pointing to aërobia as the land in which the solution of this question is to be entirely looked for. Mr. Thudichum's paper has added to those lines, and has proved beyond doubt that aërobia *can* provide all the resources required for the conversion of the sewage from its offensive solids to its condition as a perfectly harmless liquid, and that

moreover in that region the work is carried on with much less liability to offensiveness than in anaërobia.

But if that is so, does not it seem a long and unnecessary detour to go first through anaërobia when it is well known that aërobia must finally be reached before the journey is ended—or to put it shortly—should it not be the aim of the engineer to produce the most aërobic conditions possible throughout at the least possible cost?

The Author has been good enough to mention an apparatus with which my name is associated; that apparatus is an effort to secure those conditions. It is believed that instead of filling up a filter and allowing it to stand full for a number of hours, better conditions are obtained by producing a continuous series of short periodic alternations of liquid and air, and that, without the necessity of manipulating valves or adopting complicated appliances, the mere rotation of the distributing arm produces (except in the very small beds) the required alternations. Such a method is more analogous to nature than what may be considered accumulated energy, which is more usually accompanied in nature by cataclysm. There is an universal physiological phenomenon in the animal system—a system which everywhere affords examples of maximum result at minimum cost—to which it bears a close resemblance; I refer to the oxidation of the blood. The heart, by a continuous series of short periodic impulses, sends the blood into the lungs, where, by a similar series of periodic inspirations, it is brought into contact with the air and oxidised.

Whether all that is expected from the distributor will be obtained, time and trial only will prove, but at present there is every reason to be satisfied with the result.

Communicated Reply.

Mr. THUDICHUM: I desire, in the first place, to thank the Members of the Association for their kind reception of this paper, and to express my regret that my unavoidable absence in Scotland prevented me from replying to the discussion in person.

Dealing with Mr. Mawbey's remarks concerning the results of my experiments with the sewage of Leicester, I observe that the conclusions arrived at are quite what might have been expected, even if not quite in accord with the experience gained

in other places. The sewage of Leicester is a very heavy one, and, owing to one of the staple industries of the town, is presumably more resistant than that derived from a non-manufacturing district. With so great an amount of suspended solids as Mr. Mawbey indicates, a detritus tank would appear to be a necessity. I have frequently called attention to the peculiar fitness of an effluent from a coarse-grained aërobic bacteria bed for application to land, and this view is fully borne out by the results obtained by Mr. Mawbey. The experiences with the septic tank are somewhat peculiar, and perhaps some further light will be forthcoming on this head at a later date.

Mr. MacBrair's results are not by any means new. The Barking filtration experiments were carried out on settled sewage (with a minimum dose of lime and proto-sulphate of iron) which had occupied many hours in the passage through the precipitation tanks; and it has been known for years that such treatment, in the case of all ordinary sewage, is bound to be successful. The objection to it, in the Author's opinion, is the fact that sludge production is hardly, if at all reduced, and this is a point which should always be borne in mind. It is plainly shown in the course of Mr. Chambers Smith's observations that anyhow, with a domestic sewage, the sludge difficulty can be practically removed by the use of a sufficient detritus tank. Three inches of deposit only on the floor of two tanks having a joint capacity of one-third of the day's flow (or two hours of the maximum flow) is ample testimony in this regard. The Author fully endorses Mr. Chambers Smith's remarks concerning the practicability of using many various materials for the purpose of filling coarse grain bacteria beds. His views regarding the efficiency of sprinklers are not, however, borne out by the experience gained elsewhere, as for instance at Accrington and Hyde. This again is a point upon which long and careful experiment on a working scale will alone enable us to arrive at correct conclusions.

Several speakers commented on my remarks concerning the fouling of the Hampton bacteria bed effluent by its subsequent passage over land, and it was suggested that this might be due to the land being already charged with sewage matters. So far as my information goes, the land had never previously been used for sewage purification purposes, but was ordinary agricultural land. Mr. Mawbey's effluent, with ·16 albuminoid ammonia, does not apply here. The effluent from the third set of beds at Hampton

yields only a fractional part of this, and its fouling by ordinary land is readily understood. My object in calling attention to the matter is to show that a hard and fast rule as to finishing effluents on land is a mistake, since effluents can on occasion be otherwise produced which are superior to anything that can be derived from a farm.

I desire again to express my thanks to the Members, and my appreciation of the great value of the numerous observations brought forward in discussion.

LECTURE ON THE LIVERPOOL AND MANCHESTER LIGHTNING EXPRESS RAILWAY.

By SIR WILLIAM PREECE.

The Bill was before the House of Commons this session and was rejected by them. It is the design of Mr. Behr, an active energetic engineer, brought up in the office of Sir John Fowler, and who has been associated with this kind of railway now for a good many years. There are three principles involved in this lightning express railway. The first is that it is a single rail railway, it is called the mono-rail railway. The second principle involved is that it is worked by electricity; and the third principle is that it will be worked at speeds that have hitherto been scarcely dreamt of. I have a map showing the country between Liverpool and Manchester. You will see that thick line starting from the proposed station in the very centre of Liverpool, following the Dock estate to Dingle and then going through Garston, Ditchford Green, Warrington, Borton, through Salford to Manchester. The distance is a little over 34 miles. The line is in all respects as though it were an ordinary railway of the ordinary gauge. But this railway is not to be constructed of the ordinary gauge with two rails, but it has one rail fixed on trestles. I hope this section is large enough for all to see, and it is given in detail in the drawings shown on a smaller scale. The height of the rail from the ground line is a little over 4 feet. The weight of the carriage —the carriage itself is shown in these drawings—is carried on that single rail, and on each side of the trestle there are four guide rails of light section against which guide wheels touch and rotate. When going round a curve set in that direction the wheels will press on those two guide rails, and when on the other side on the other two guide rails. The whole object of this structure is to bring the specific gravity of the coach below the centre of support and to allow the coaches to go round curves with safety and security.

On the ordinary double line you know why high speeds

cannot be obtained. It is due to the tendency which a fast train has to fly off the rails by centrifugal force. The principle of the bicycle is the tendency of rotating wheels to maintain themselves in the same plane. You who are bicyclists know the feeling of going away from the plane of rotation. In ordinary railways they check this by raising one of the rails a bit to get gravity to oppose this centrifugal force. It is this danger in curves on our double lines which has lessened the speed of working more than anything else. On this mono-rail line there would be no such danger. The only effect of going round a curve is to increase the resistance between the wheels and the guide line. It would affect a little the speed of a train, but it is absolutely secure, and would prevent the train going off the line. The train consists of only one coach; weighs 45 tons and carries 100 passengers. The details are all given in the drawings, which show also the electric connections. Now the engineering structure of this line follows the practice of a line in Ireland. There is a line of short length from Listowel to Ballybunnion in County Kerry, not far from Limerick. That is a line 9½ miles long, in fact it is a small locomotive tramway. The train consists of four coaches, and it has been at work now for 13 years. I went and inspected that line in the early part of the year, and I found the rails, everything, put down thirteen years ago are there still; there is not a single rail that has even been turned; there is scarcely an indication round the curves of any friction between the wheels and the guide rails, and altogether the mechanical experience of that line is such as to justify the conclusion that there is nothing mechanically wrong in an engineering sense in this structure, and nothing to prevent it fulfilling its duty between Liverpool and Manchester.

Another peculiarity of this line is also this; there are no intermediate stations; there are no crossings; no points; the line runs from Manchester to Liverpool without interference of any sort or kind. There will only be one set of signals at Warrington; where the electric generating station is to be fixed; where the workshops are located, and where they will be obliged to have sidings and points to repair the carriages if they get out of order. With that exception there is no necessity for any intermediate signals of any sort or kind on the whole length; the only other fixed signals being at the two

terminals. Then it will work at the speed we hope from the fact that it is fairly straight. There will be curves at each end, though they will not be material. There will thus be this single uninterrupted line, and it will be only necessary to get up speed at the one end, and then run through without stoppage at the rate of 110 miles an hour. Well, many people have thought a speed of 110 miles an hour is something dreadful to contemplate; speeding through the air at such a velocity many people imagine the passengers can scarcely keep their seats; but as a matter of fact there is no doubt whatever that on many of our lines now going down inclines we frequently get speed up to 80 miles an hour. In America it is recorded that the Empire State Express on the New York Central line from New York to Chicago has acquired a measured speed of 110 miles an hour. On this or any other line unless you have your eyes fixed on the telegraph posts you have no idea of the speed at which you travel. You get in your coach, and whether your coach is going 10 or 100 or 200 miles an hour, your body has acquired the same speed as the train, and there is no reason to feel any effect whatever from the highest speed. So we have every reason to believe, with the character of the coach, with the traction due to electricity, and with the straight length of line, that passengers will be carried at 110 miles an hour between Liverpool and Manchester without the smallest feeling except that of greater comfort than that of travelling on the existing lines; greater comfort, because we shall not be subject to so much vibration due to the action of the locomotive. The steadiness of the single rail with its guide rails is superior to the steadiness of an ordinary double line coach.

As to the electric traction, there are two reasons why electric traction is superior to steam traction. The first is that where you apply electric traction, you bring at once on your driving wheel the whole of the power at your disposal. You can at once with merely turning a switch apply 2000 horse-power to your driving wheel. With steam locomotion you can do nothing of the kind. It takes time to apply your steam; it takes time to get up your power; and the sudden application of the entire force at your disposal is quite impossible in any form of steam locomotion. The second advantage is this: that with steam locomotives the application of

your power is variable; it passes through the zero period owing to the reciprocating action of your cylinders and pistons. There is nothing of the kind in electric traction. It has a constant torque. In the steam engine the torque is variable; but in an electric motor applied to a tramway, or the driving wheel of a locomotive, or any coach of any kind, the torque is absolutely continuous. It gives a constant bite on the rail. It bites the rails with the whole force. It means this, that while the practice on our railways is to accelerate the train at about 6 inches a second, and it is limited to 6 inches, for I have no instance of a steam locomotive going more than 6 inches a second, with electric traction you can get any acceleration you like, and it is only limited by the jump which the passengers get if applied too suddenly. On the Metropolitan Railway, we have been getting an acceleration of 1 foot per second; on the Central London Railway, owing to their being helped by the down grade, they have succeeded in getting 1½ foot per second, and on the City and Waterloo Railway, where we have single motor coaches, fitted with powerful motors, we have got up to 2 feet per second. There we find, when you exceed 1½ foot per second, you getting an unpleasant shock at starting. That teaches us you must not exceed 1½ foot per second in starting or stopping your train. Our central station would be at Warrington, the current would be transmitted in three core cables to Liverpool in one direction, and to Manchester in the other direction; and every 3 miles there will be substations, where the current transmitted from Warrington will be stopped down by transformers to 1000 volts. The coach as it goes along will pick up this 1000 volts, working on the three wire system, working really each motor with 500 volts; and the current will most probably be applied directly to the motors on the car. There is only one line that I know of at present worked on this system. It is in Switzerland, and it works so well there is no reason to doubt that it is applicable to this line, and it will be similar in every electrical detail if we should succeed in transporting the three-phase alternating current from Warrington to the transformers straight on to the locomotives, and work the train by alternating currents. There is one reason why we should not work alternating currents on ordinary railways. The reason is, with the alternating current you cannot get the rapid acceleration that you do with continu-

ous currents. The sudden application of power is smaller with alternating currents than with continuous currents; but on this line the question of acceleration is not so important as where stoppages are frequent, as on the Underground Railway. The stoppages on the Central Railway, between Shepherd's Bush and the City, amount to seventeen, and on the underground line of the District Railway they amount to twenty-six or twenty-seven. Therefore, when you get all these stoppages you want to make your acceleration as rapid as possible.

So far as regards the mode of working, there are, of course, dangers in all systems of working railways. The first danger, with which most of us are familiar, is that of collisions. On this line, where there will be only one train on a section at a time, there will be no possibility of collisions. It is intended to run from Liverpool to Manchester in twenty minutes; the trains will start every ten minutes; and the result will be after a train has left Liverpool, it will have passed Warrington in ten minutes, and the line from Liverpool to Warrington will be safe for the second train to go through, and there will be an uninterrupted passage of trains between Manchester and Liverpool on the double line, a continuous circulation of trains, all kept apart by the distance between Liverpool and Warrington, because Warrington is very nearly the half-way house. Thus collisions will disappear. Then another danger is that of derailing. I have explained that, and shown how derailing is practically an impossibility, and we shall feel very secure against that cause of accident. Again, another source of accidents on railways is at junctions and points, trains so very often get off the points. Here there will be no facing points, and no accidents from that source. But, perhaps the most frequent cause of accident on railways is the mistakes due to individuals. In all our spheres we are all subject to error. And the poor signalman, on whom we rely for our safety, does occasionally make mistakes, and when he does the result is very serious. Here we are not relying on the signalmen, and these four causes of accident are removed from this line. When bringing this matter before the Committee, it was suggested there might be such a thing as a tree falling across the line. My answer was that you must cut all the trees down, so that no trees can possibly fall across the line. You do not know what will occur, for the unexpected always

does occur, and you want some power which will stop your train in a reasonable distance. This was a subject which occupied the minds of the Committee of the House of Commons. Very unfortunately we had not much experience or knowledge gained to answer their questions very satisfactorily, but we have since found from evidence in England and America that there is no difficulty whatever in stopping a train going at 110 miles an hour at distances comparable with trains going at less speed. On the train there will be a Westinghouse air-brake, and that applies to the wheels cushions that bring to bear a retarding force of about one-tenth of the weight of your carriage. That alone, without any extraneous aid of any kind, will enable your train to stop in 900 yards, but in addition to that you have on your coach two motors each of which can be reversed. Thus your motor, instead of acting as a motor torque, can by its own velocity be converted into a dynamo. If you suddenly stop your current driving your train, your motor, by the revolution at enormous speed, becomes a dynamo, and it generates currents itself. So if you reverse your motor, instead of being a motor by torque, it becomes a dynamo which acts as a check and becomes an electric brake, and will without any doubt whatever with the air brake stop this train, going at 110 miles an hour, in 500 yards. That I think is quite within the bounds of practice and quite good enough for our purpose. I need not weary you about the costs of working this line. It has been very carefully estimated; the estimated capital cost is about 1½ millions sterling, and the working expenses will come out at less than the working expenses of other lines, because you have removed the great cost of stations, porters, signalmen; your plate-layers will be the same as other lines, the power is concentrated on one light locomotive; you will not have forty or fifty locomotives wasting coal; and, with a rapid, smooth and pleasant journey, this railway would attract, probably, all the business passengers who want to make their journey rapidly. The trains will be loaded with express traffic, that will be worked at low cost, and the result must be that this line will prove to be commercially successful. It has been thrown out this session, probably to come up again next session. The promoters will be better prepared then, but whether they fail or whether they succeed, all we know is that they have proposed a great step in advance.

We must anticipate on our railways greater security, greater speed of travelling. It is within our reach, and when we have a practical thing of this kind within our reach we cannot remain idle until the British people possess the right of using such a great advance of applied science.

DISCUSSION.

The PRESIDENT formally moved a vote of thanks to Sir William Preece for his interesting lecture.

Mr. E. J. SILCOCK : I have great pleasure in seconding the vote of thanks to Sir William Preece. We are all deeply indebted to him for coming here and lecturing to us in this very pleasant manner, and giving us such a good idea of this proposed novel railway. I say novel, because I was not aware until Sir William mentioned it, that a line had actually been constructed on the principle of having a single rail, but at all events, we do not see it in England. I do not think the principle in itself is novel to engineers; I remember some years ago, it was suggested in a Bill for an elevated railway for Leeds to replace ordinary trains on somewhat the same principle. The weight of the car was carried by a single rail in precisely the same manner as is shown in this diagram of the permanent way, but the arrangement of the guide rails was different. There were two guide rails instead of four, and the road was carried on girders, and the guide rails formed a proportion of the lower booms of the girders carrying the railway. The guide wheels, instead of being placed vertically, were fixed at an angle, and I should say the arrangement shown here would be far preferable to having the guide wheels fixed at an angle, because any vibration of the springs would be much less felt in this arrangement, where the guide wheel would slide over the face of the rail vertically. I should like Sir William Preece to explain further one point which he made in favour of electric traction. It was that the full power could be applied at once for the purpose of starting a train. I quite see that the full torque could be applied, but the full power, it seems to me, depends upon the speed at which the motor is revolving. Therefore, until the machinery is at full speed, I do not see how you could get full power. If Sir William Preece would explain that I think it

would be instructive. With regard to the question of signalling, I take it there would be just this danger on this railway. If there were a half-way house or station at Warrington, there must be a set of signals to signal the fact that the train has passed the half-way before the next train is started. That must be a point of weakness, and if the line could be cleared the whole distance, it would be eliminating that weakness, to a certain extent, and might probably do away with some danger which the Committee of the House of Commons evidently thought there was; because when this novel project is first started, a twenty minutes service might be sufficient, and as experience proved it manageable, then the number of trains might be increased and this restriction removed. I, for one, was extremely sorry that the House of Commons threw this Bill out. I think it would be extremely interesting to have this railway running, and I hope the Bill will be revived again in another session, as suggested by Sir William, and will be received more favourably than this present session. As has been pointed out, we do get speeds on our railways approaching the speed it is proposed to run. I have timed trains up to 78 miles an hour, and friends of mine have timed them at even higher speeds. I know from Grantham to Peterborough on the Great Northern they regularly run 78 miles an hour, so it not such a mighty step to advance from 80 to 110 miles an hour, and I hope we shall see this project carried through.

Mr. A. E. Collins: I should like to support the vote of thanks to Sir William Preece for this interesting description of the mono-rail. I take it there must be points at Warrington, and at the two ends of the system to enable cars to pass from the up to the down lines. If Sir William would show how it is proposed to construct those points, it would be very interesting. Sir William gave a very interesting comparison of the irregular torque of the steam engine with the regular torque of the electric motor, but is it not a fact that the torque of the steam turbine is equally regular?

Mr. MacBrair: Are we to understand that, as there will be no points on this railway between Liverpool and Warrington, there will be no signalling stations on that section of the line, and therefore no means of preventing following trains running into another, which may have broken down or otherwise come to a standstill?

Mr. Caink: I should like to ask what is the greatest distance between the sub-stations, and the shortest distance between them.

Mr. J. Price: I should like to ask a question with regard to the terminal stations on this railway at Liverpool and Manchester. I happened to be in the Committee Room of the House of Commons when Mr. Stenning was giving evidence, and it was elicited from him, by the counsel for the Salford Corporation, that this proposed railway would be 75 feet above the water level at the wharf belonging to the Salford Corporation. I should like to ask Sir William what he thinks it would be like to have a railway of this kind fixed at that height in the suburbs of a large city.

Mr. E. G. Mawbey: I do not wish to go very closely into this question, but I should like to say a few words of gratitude to Sir William, as a Past President of our parent Institution, for the trouble he has taken to come here at a time when we are all thirsting for knowledge of electricity. We have in the past been very glad of a friend at court in the Institution of Civil Engineers. It appears to me we need a friend now to help us with this difficult question of electrical engineering, and we ought to heartily express our indebtedness to Sir William Preece for coming among us and giving us particulars of this novel scheme of electric traction. I have had very substantial proof of Sir William Preece's kindness, as a friend to Members of this Association. I should like to know a little more about the power station, the alternating current, and so on. I do not know whether the promoters are so advanced with the scheme as to be able to give particulars as to the machinery. If so, one question I should put is as to the type of engines and generators to be used. I should like to know whether it is contemplated to go in for the vertical type or the horizontal type of engines, and also a little about the generating plant. I also desire to express—having recently been occupied with the consideration of this question of electric traction—my hope that when this scheme does go through, the electrical work will as far as possible be done by the firms of our country.

Mr. Turley: I may say that I shall very possibly be assisting in the opposition to this scheme next session, and I should, therefore, like to put one or two questions to Sir William Preece. I have heard it stated, that there is likely to be considerable

danger to any person who walks across this railway from effective currents. Then another objection on the part of Eccles, the corporation I shall oppose for, is that it is proposed to carry this railway parallel with the ship canal. The town of Eccles is looking forward to progressing very rapidly, and you know if you have a railway built only five feet above the level of the ground, which amounts practically to a solid wall, access to the canal from the town is completely cut off, and consequently Eccles would be damaged thereby. I want to know whether it would not be possible to have the railway so raised that vehicles could pass without hindrance between the canal and the town.

Mr. J. T. Eayrs: I think we are more particularly interested in the description Sir William Preece has given to the Association this morning, more as a matter of principle, and not as directly affecting Liverpool and Manchester. The last speaker has applied this case to Eccles, in which he is or was professionally interested, and the first question he asks is what happens if a trespasser gets on the line. The Members will remember what Stevenson said as to the cow, and I suppose the fate of the trespasser will be very similar to that predicted for the cow. I had no idea that a line on this principle had already been laid in the United Kingdom. I apprehend that the line which has been spoken of as laid in Ireland, is nothing to be compared with that suggested in this scheme, and altogether any comparison of that line with this would be fallacious. The district in which that line is laid is probably one with very little traffic, and if the scheme as proposed here is carried out, there is no doubt there would be a large accession of traffic between Liverpool and Manchester. The one matter that struck me more particularly, is that referred to by Mr. Collins as to the details of the points. There is no doubt a line of this kind would not be generally used in the country, except as a means of communication between one large centre and another; it could not come into general use owing to the very high speed attained and the difficulty of providing intermediate stations at short distances, requiring the stopping trains at those high speeds. There would be, of necessity, points to divert the traffic from one line on to a branch, and there seem great practical difficulties on the sketch which I see before me in providing crossings on this mono-rail principle. It seems to me a very difficult mechanical engineering problem,

and one that would be no doubt accompanied by danger in having a proper connection between these branches. One would have liked to have seen the detailed drawings, showing how this was proposed to be effected. I do not see any difficulty at either the Liverpool or Manchester end, because instead of having sidings or crossings they might simply have a loop from the up to the down line; there must be difficulties in having no intermediate stations, because you cannot collect any traffic on the way. Whatever Warrington may desire, or however much it may increase, you cannot take passengers up without stopping the train. I think this railway would be useful only for passengers, and it is a question of passenger traffic only.

The vote of thanks having been accorded by acclamation,

Sir William Preece: I am very much obliged to you for receiving my work so kindly. I will endeavour to answer the number of questions that have been put to me, and if I fail to answer them to-day I will do so in another form on another occasion. As to the prior application of this principle, I remember very well the scheme Mr. Silcock refers to. At the present moment in Germany through the town of Dusseldorf a railway on this mono-rail principle is carried over the river, supported on girders of fifty to a hundred feet in length. Mr. Silcock asked one important question, why is it in electric traction you can apply your torque at its maximum at once? The reason is this, your power is simply dependent on the electric motive force and the current. The electromotive-force is in this case 1000 volts, fixed and constant. Supposing your maximum current is 1000 amperes, the mere turning of a switch will at once apply on your motor the force of those volts and amperes, viz. 1000 kilowatts, and it is applied instantaneously. With the electric motor you have the instantaneous application of 1300 horse-power at your disposal. That is not so with steam. Steam takes time to go through your engine. It is quite true a Parsons turbine will give you a force similar to that of the electric motor, but that has only been applied to fixed and stationary engines. It has not been applied to locomotives. But there has been an attempt to apply the principle in France, on the Northern Railway of France, by the Heitmann locomotive. There was a vertical engine, a Willans engine, also an electric motor fixed on the locomotive. The

result was fairly satisfactory, but it was not adopted practically. You may take it as an absolute fact in all questions of electric traction, whether it be a tramway or an electric railway, by the turning of a switch you can apply instantaneously the maximum power at your disposal, and that gives you an immense advantage over steam. Mr. Silcock also referred to signalling security. Well, I had only half an hour at my disposal. If I had had three-quarters of an hour I might have referred to signalling. We propose to insert a sub-station every three miles. We have not gone so far as to determine whether three miles is the economical limit between the two, we have only guessed at it. Every three miles will be made a branch section, and the train as it goes through will make the three-mile section behind it secure, for there will be no current on the section. At the commencement of a section the train will be pulled up because there is no current to work it, and the driver will have a clear indication before his eyes that the line is either clear or blocked. He will have an indication for three miles before, and he will know the three miles behind him is safe because there is no current. It is, I believe, the most perfect system of block signalling at your command. In answer to another question, supposing an accident takes place: you have a telephonic circuit, and if from any cause a train stops the driver will simply have to put two hooks on the telephonic circuit to enable him to speak to Warrington and to each end of the line and tell them what is wanted. Then it is practically possible to maintain communication by speech from the train in motion to either end of the line; they will have power of speaking when the train is moving and when the train is broken down—every possible security that modern science can place at their disposal. Mr. MacBrair referred to the question of points. I cannot say the details are sufficiently advanced. I cannot answer the question, as a matter of fact. On the Listowel and Ballylongford line—which, although on a small scale, is almost identical to this, except that there are two guide rails instead of four—there are turntables and points, and the whole thing is done on the turntable arrangement. Supposing there is a mono-rail 10 feet longer than the coach itself, the rail is fixed as a turntable on the centre and turned round to a point leading to the workshop, and away the coach goes there. There are goods stations and that sort of thing, and each coach is pushed on to its proper rail.

There are forty-two level crossings in this nine miles between Listowel and Ballylongford. We may be on opposite sides next year. If he wants to have my views he must wait. At the same time, I quite agree we were thrown out by Salford. The committee who considered this matter said they did not throw the Bill out on any technical point, they threw it out on the opposition of the Mersey Dock Board, with whom the promoters had not made a proper agreement, and on the opposition of Salford because the scheme had not been properly considered with regard to Salford. He has brought a very proper point before you, the necessity of preserving the freedom of traffic arrangements between two places. If a railway cannot be carried over without causing interruption of traffic it must be carried under. The committee were very insistent upon bringing the railway into Salford by tunnel, but the great difficulty with a tunnel is that your air-resistance increases so greatly that high speeds in a tunnel are impossible. The experiments made on the Central London Railway show that the resistance of the air in a confined space in a tunnel is very serious and very difficult to meet. Of course it may be possible to meet the objections of Eccles on the one hand and Salford on the other, and as regards the Mersey Dock Board I have reason to believe the difficulties have been settled. Mr. Mawbey asked as to the type of machinery. We have not gone so far as that. I think the thing for new institutions is not to submit for tenders a complete scheme designed by an engineer. What you want in a case of this kind, what you want in introducing electric traction into your various localities, is to be able to court the assistance of the whole world. I am very strongly in favour of doing this in all cases of electric lighting, and I shall do so with all cases of electric traction. My intention has been to issue an open specification which will attract tenders from everyone. We want to get experience: we do not want even to confine it to our own country. We want to get experience where experience has been gained. The Americans are a generation ahead of us. Switzerland is ahead of us. I do not think Germany is so far ahead of us as people think. But there are people who are ahead of us, and we must get ahead of them; and we can only do it by taking advantage of their experience. My idea in introducing these notions is that we must do all we can to find what other people have done. As to trespassers that question has been answered, but there are officials who must

necessarily cross the line, and if there is any danger they must be subject to it. I gave evidence before the committee to show that there is no possibility of any man receiving beyond 500 volts. Five hundred volts is almost universally applied all over the world, and there is no one single record or case where a man has been damaged by a current of 500 volts passing through him. I can speak with experience because I have had 2000 volts through me. I do not want it again, it is not a very pleasant experience. I have taken 1000 volts without inconvenience, and on the Metropolitan Railway I applied my own hand and experienced no inconvenience. I can say as to trespassers and officials that line will be absolutely secure.

LIGHT RAILWAYS,
FROM A COUNTY SURVEYOR'S POINT OF VIEW.

By H. T. WAKELAM, Assoc. M. Inst. C.E.,
County Engineer and Surveyor of Middlesex.

In submitting the short paper invited by the Secretary of the Association, the Author would state, that amongst the many additional duties which have devolved upon county surveyors since the inception of county councils, on the passing of the Local Government Act, 1888, nothing has come under his notice of greater importance than the formulation of a light railway scheme under the Light Railways Act, 1896.

In March 1899 the Author was asked by his Council "To consider in what way the County Council may, in the interest of the County at large, avail itself, as promoter, of the provisions of the Light Railways Act, and to prepare a scheme for that purpose accordingly."

On giving the matter full consideration, the parliamentary committee of the Council was satisfied with the feasibility of such an idea, and of its proving a great success, both from a workable and financial point of view.

It will be remembered that the Tramways Act of 1870 confers no power by which county authorities may promote tramway bills in Parliament, and therefore the Light Railways Act of 1896 is the only legislative measure under which such authorities may seek power to construct lines, or, in other words, tramways; such power being obtained under an Order from the Light Railway Commissioners, after a public inquiry has been held by them; the Order having to be formally confirmed by the Board of Trade before it comes into operation.

By the Public Health Act, 1848, all England, town and country alike, was for the first time brought under defined sanitary supervision, fairly comprehensive and complete.

By the Public Health Act, 1875, advances were made in

several directions, when urban and rural sanitary authorities received permanent recognition. The functions of each were gradually developed until 1888, when county councils were constituted by the Local Government Act.

There are now existing, as the result of the Local Government Acts 1888 and 1894, three principal units of local government, viz.:—

(*a*) County Councils,

(*b*) District Councils,

(*c*) Parish Councils.

The term "County Council," as you are all well aware, applies to the governing body of a county, and to any borough having a greater population than 50,000.

Up to the passing of the Local Government Act, 1888, fifteen Acts dealing with highways had been passed, commencing with the general Act, 1835.

The Public Health Act, 1875, vested the powers and duties of surveyors of highways and of vestries, given under the Highways Act of 1835, in the urban authority.

The Highways Act, 1878, abolished turnpike roads, and for the first time the county authority (then the Justices sitting in quarter sessions) was called upon to contribute towards the cost of the upkeep of main roads.

Section 11 of the Local Government Act, 1888, prescribes that all main roads shall vest in and be repaired by the county authority, unless district councils claim to retain power to carry out repairs requisite to the main roads lying within their areas, under which circumstances the county council shall pay the reasonable cost incurred. County councils, therefore, may rightly claim to be the authorities most interested in the upkeep and welfare of the main roads.

The Council the Author has the privilege to serve, in an official capacity, was the first, and seems to be the only county authority, other than county boroughs and the County Council of London, that up to the present has prepared an entire scheme and has sought to obtain Orders from the Board of Trade to construct light railways and to become primarily the tramways authority of the county.

The population of Middlesex has increased by leaps and bounds during recent years, and such a vast increase may be put down to—

(1) The semi-Metropolitan character of the County;
(2) The lowness of rates;
(3) The good administration of the various authorities; and
(4) A gradual exodus of people caused by the acquirement of what were residential blocks in London for conversion into business premises.

The great increase of population referred to has been the cause of speculative companies promoting the numerous applications for Orders submitted to the Board of Trade, to empower the said companies to construct so-called light railways along the main roads. The introduction of electricity as a cheap motive power has no doubt also been a great factor in the promotion of the increased number of applications.

The County Council of Middlesex has always consistently opposed company-controlled undertakings, as being in direct opposition to the interest of the county at large. It is felt that the main roads are costly to maintain, and that the large profits that accrue from tramway undertakings should be enjoyed by the ratepayers, whose property the roads are, and that the lines of communication should not be given up to private companies.

When it became known that the Board of Trade had determined to stand by their interpretation of the term "Light Railways," means presented themselves by which the county could be benefited; such an interpretation having already given a private company about six miles of tramways in the western portion of Middlesex at a much less cost than tramways could have been promoted. This also relieved the company of the restrictions placed upon tramways with regard to purchase, by Section 43 of the Tramways Act, 1870.

On the recommendation of its parliamentary committee, the County Council of Middlesex decided, by resolution, to become the light railways authority, and adopted the Author's scheme, which has a total length of about 103 miles, of which certain sections have already received the approval of the Light Railway Commissioners.

The sections of the scheme already approved are entirely devoid of speculation, and will become a source of assured income from the date of their completion, owing to the terms of an agreement already settled with a company prepared to lease the lines.

The Council have determined to construct the railways, but not to work them at present. Arrangements for leases to private companies will probably be made. It is considered advisable to do this instead of creating a special department to deal with the matter. Whatever its disadvantages, a lease, settled upon a profit-making basis, is less risky than forming a department entirely devoted to the supervision of a tramway system. Ratepayers may satisfy themselves that there is nothing speculative about an undertaking worked on such lines.

Middlesex may truly be termed semi-Metropolitan in character, and it is of the utmost importance that as many travelling facilities as possible may be given to the enormous number of people who, more or less, live in the County of London but sleep in the County of Middlesex.

With this object in view the Author's scheme included all the main arteries, so that direct communication may be had with, and running powers arranged over, any lines the County Council of London may construct.

It was seen that grave difficulties would arise in creating a thoroughly workable and efficient system if the provision of light railways and tramways were left in the hands of private companies, and also if the local authorities promoted short lengths within the areas of their respective districts. These difficulties were also anticipated by such far-seeing men as the Chairman of the Hornsey District Council and other representatives of local bodies, and projected railways within their districts were dropped in favour of the County scheme, directly the extreme value of the latter was appreciated. Its inception and accomplishment are due to the foresight and energy of the very able and much-esteemed Chairman of the County Council, Mr. R. D. M. Littler, C.B., Q.C.

There is no doubt that, for advantages and convenient working, a uniform system under one authority is eminently the one to be desired.

It appears to be the general opinion that county councils should take the place of private companies in light railway or tramway undertakings, and so relieve the ratepayers as much as possible of the cost they have to bear in maintaining their main roads.

Light railways and tramways are, no doubt, a source of

considerable profit, otherwise private companies would not so readily grant such concessions as those already offered by them in some parts of the County of Middlesex.

There is no law by which companies can be compelled to cleanse and water the tracks laid down; and therefore, although the control of the track repair devolves upon the company interested, the cost of scavenging and watering devolves upon the Council, and it seems unfair to the ratepayers to allow speculators to take possession of what no doubt is, in most cases where the lines are laid, a source of considerable income to the promoters.

It is seen that if companies can pay such large dividends and make such concessions as have been offered by them in various directions, the County Council of Middlesex may have very strong faith in its contemplated projects.

The effect of any county council becoming the light railway or tramway authority will be, to enable that council not only to place at the disposal of the inhabitants within its area the best possible cars that can be purchased, and which can be kept free from the hideous advertisements and disfigurements which are invariably associated with company-controlled undertakings, but to provide cross-connections, which a company working solely for profit would not entertain.

A county scheme can insure uniformity of rates and fares throughout the system. Cheap trams for workmen can be conveniently arranged and insisted upon. Cleanliness of the cars can be assured. A thorough system of supervision to ensure comfort in travelling can be instituted. The whole of the materials employed, the method of construction, and the positions of street standards, can be pre-arranged with the district councils interested, without reference to the Board of Trade under arbitration clauses.

Stopping-places can be more conveniently arranged, after the due consideration necessary has been given to insure the requisite facilities for the ordinary road traffic—which is oftentimes altogether overlooked by private promoters.

Regulations for rates of speed and punctuality can be framed and enforced, and fares for travelling on Bank Holidays, etc., can be definitely settled. The latter is a most important point—companies invariably charging exorbitant fares on those occasions.

Double and single tracks can be laid, whichever appear most suited to the road widths, without large expenditures being cast upon the exchequer of the county by having to contribute to local widenings necessitated by companies carrying out short sections to the advantage only of the people resident in one or two districts, and not to the county as a whole.

Private companies, as a rule, go for the "plums" which in a county scheme can be put in with the "paste," and still create a paying scheme and give greater advantages to the public than company-controlled undertakings are likely to give.

Intercommunication, as already stated, can be provided, which, with small schemes, would be practically impossible; and last, but not least, equal benefits would accrue to the whole county—the profits, which undoubtedly would be reaped from such an undertaking, going towards the relief of the county rate.

There are many more minor considerations in favour of a county scheme that might have been treated, but as the Secretary desired a short paper only, it has been the aim of the Author to confine himself to the most important points and to be as concise as possible in his remarks.

It is contrary to public policy to grant monopolies over main roads; and, therefore, if the latter are to be used for the purpose of light railways, the system laid down should, in the Author's opinion, be as far as possible a complete one, and should be carried out by an authority representing equally the interests of all districts within the area to be dealt with—in other words the county council.

DISCUSSION.

Mr. J. Price: I will move a vote of thanks to Mr. Wakelam for his paper on the subject of light railways. I quite agree with him in his contention that a county authority responsible for a wide area can deal with the tramway question in a more efficient way than a number of small authorities acting independently of each other. But Mr. Wakelam, instead of dealing with the subject in a comprehensive manner, has strung together a lot of details which usually appear in the leases between the

local authorities and the tramway companies. I must admit myself to be extremely disappointed with the paper, because I expected to obtain some useful and up-to-date information as to how these light railways would affect one's own county. The paper entirely misses the important questions of population, mileage of towns, cost of construction of trams, and the proposed profit which presumably they do get, and which the Bill when before Parliament would have to estimate and provide for. If that information was given then the paper would be useful, and they could estimate for themselves as to whether the abnormal conditions of a metropolitan county like Middlesex would form any sort of basis for dealing with the tramway question in such a county as Warwickshire. Mr. Wakelam seems to have missed all this really useful information and dealt only with such matters as may now be considered settled points, seeing that municipalisation is at present so fashionable, and the result is that the discussion can only be one of general politics.

Mr. A. E. Collins, in seconding the vote of thanks to Mr. Wakelam: I think this system of constructing and working of tramways is more likely to give satisfactory results than any other. I have had personal experience of tramways in four different towns—in some of the towns they have been constructed and worked by the companies, in some they have been constructed by the local authorities and leased to the companies. The latter system is the best. It avoids the establishment of a distinct department, and it gets over the difficulty of having the fares fixed by the local authority. A company is not subject to so much trouble in the matter of wages and fares as a public department. Several towns which own and work the tramways have been worried into charging lower fares than they can work the tramways at. It would be interesting to know what towns Middlesex is going to couple-up with its system of light railways.

Mr. C. Jones: I must give Mr. Wakelam credit for acting the part of a good special pleader very considerably in this paper. He has opened up much that is useful, but he would have made the paper even more useful if he had given us the detail and told us not only what they have done but what they are going to do. It would have been particularly interesting to me to know what the Middlesex County Council are going to do. I have no doubt when the network of light railways in Middlesex

is complete, twenty-four years hence, we shall be able to ascertain something of interest then as to the mode of manipulation, that is to say, if the County Council is then in existence to deal with this gigantic question. In Ealing we were so interested that when this question of tramways came up we came to terms with and left the development in the hands of a large company, and we are of opinion that in the end we shall be satisfied with well-nigh everything that has been done. To sum up the position in a few words—we shall look upon a development which we did not regard at first as desirable to the district, as a boon to the public at large. From the mode in which it has been manipulated, and the class of carriage to be used, we have reason to believe that it will be an immense improvement upon every class of locomotion we have had to deal with hitherto.

Mr. Yates: I should like Mr. Wakelam to make clear what appears to be a contradiction in his paper. He contends that the large profits accruing from tramway undertakings should be enjoyed by the ratepayers, and then proceeds to say his Council will not work the tramways but will lease the lines to public companies. The leasing of lines is usually on a rental, based on a percentage of the cost of the undertaking, and whatever profits accrue from the working would be more likely to go into the pockets of the company than of the County Council. I quite agree with the Author of the paper that it is very undesirable that district councils should hold or work short lengths of line in their own district. It is better to have through communication—this is likely to give better results all round.

Mr. Wakelam: The beginning of Mr. Price's criticism appeared to be rather scathing, though, after being considered, it simmered down to nothing. The system of light railways we propose for Middlesex may not suit Warwickshire—but let Warwickshire speak for itself. There are forty English counties; and, setting Warwickshire on one side, there are other counties which might make use of a similar system to that described in the paper. It must be remembered that the question of light railways in Middlesex is just in its infancy, and we have nothing as regards profit and loss to show, but we have an agreement with a company to pay us a good percentage on our capital expenditure before they take a penny for their profit.

Mr. Price: How much?

Mr. Wakelam: If it is of interest and value to the Members of the Association I could have a *précis* of the agreement appended to the paper, which may help Mr. Price out of his difficulty. I am glad to see that Mr. Collins agrees with me that such a system is one much to be desired. With regard to Mr. Jones, he and I have had rather a tussle over the matter. Ealing saw fit to go over to a company. They have got promises which may satisfy them for a time, but I do not think that eventually they will be satisfied. To my mind it is infinitely preferable that all matters of an engineering character affecting the interests of district and county councils should remain in the hands of such bodies.

SEWAGE PUMPING MACHINERY AT RICHMOND.

By W. FAIRLEY, Engineer to the Richmond Main Sewerage Board.

The drainage district of the Richmond Main Sewerage Board comprises the six parishes of Richmond, Kew, Petersham, North Sheen, Mortlake and Barnes, all in the County of Surrey, with a total area of 4983 acres, an assessable value of £385,493, and a permanent resident population estimated at about 50,000; during the summer months the population is, however, largely increased.

The first four parishes mentioned are under the jurisdiction, as urban sanitary authority, of the Corporation of Richmond, the remaining parishes being under the Barnes Urban District Council.

The local authorities are responsible for providing and maintaining the sewers necessary for the efficient drainage of their districts, the Main Sewerage Board being required, by their provisional order dated 1887, to provide main trunk sewers to intercept all the sewage from the local sewers, and also to provide sufficient pumping machinery and other plant for its purification and discharge to the River Thames.

The sewers of the Board are laid at sufficient depth to intercept the drainage from all parts of the united district, and convey it by gravitation to a point in the parish of Mortlake, adjacent to the River Thames, where pumping machinery is provided, and the whole of the sewage raised into tanks, and treated by a process of precipitation and filtration before being discharged into the river.

The sewers vary in size from 12 inches to 40 inches diameter, and are constructed of stoneware pipes encased in cement concrete, brickwork and concrete, and, where laid along the river banks, of cast-iron pipes.

The gradients vary, according to the sizes of the pipes, etc., from 1 in 250 to 1 in 1200.

The main joint-sewer, where it enters the pumping-station, has a capacity of about 12,000,000 gallons per day, calculated on the flow due to the gradient.

Pumping Machinery.

When the Author took charge of the works, in 1891, the pumping machinery provided for raising the sewage consisted of three sets of pumping engines, each being capable of lifting approximately 4,000,000 gallons per day from the well to the high-level delivery channel. The bottom of the sewage well is 25·00 feet below ordnance datum, and the bottom of the delivery channel 18·00 feet above ordnance datum.

The total pumping capacity, without allowing for any reserve, was therefore about 12,000,000 gallons per day, and this amount had, up to that time, been considered a fairly liberal allowance for all immediate contingencies, the dry-weather flow averaging about 2,500,000 gallons per diem.

After the works were in full operation, and the district sewers connected to the main sewers, it was seen that the plant would soon be unable to cope with the large quantities of water flowing off the district during heavy rains. The circumstances were rendered more urgent by the fact that a large portion of the Board's district, where adjacent to the river, is not much above (in fact, in some places below) the level of the water in the River Thames during high water of spring tides. Under these circumstances, about the period of high water, the only possible outlet for sewage and rainfall was by means of the pumps, as no storm overflow would be available—and, in fact, none had been provided.

In 1892 the Board proceeded with the construction of two storm overflows, one on each of the main trunk sewers where adjacent to the river.

The cills of these overflows were constructed at 5·00 above ordnance datum, but, as the level of the sewer at the works is 19·19 below ordnance datum, the sewers are practically filled nearly to the manhole-covers before an overflow can take place to the river, even at low water.

These overflows were constructed of 21-inch stoneware

pipes, and fitted with the usual cast-iron tidal flap valves, inspection chambers, sluice valves, etc. In 1897 three additional outlets were constructed on the river side, Richmond.

Although only available for the period of time that the river water is about or below half-tide, and their usefulness therefore limited, they have on several occasions, when heavy rain-storms have occurred, reduced the danger of flooding in adjoining low-lying areas.

By the Board's provisional order, in addition to being under the necessity of constructing works for the sewage from the united districts, they are also required to take rain-water falling on roofs, areas and yards of buildings, or from house areas below the surface of the ground.

Each constituent authority has, at considerable expense, constructed systems of surface-water drains, by means of which all the road-water is discharged direct to the river. At the same time, although the separation of the road-water relieves the sewers to a large extent, the water from the roofs, etc., forms such a considerable portion of the total rainfall, that the benefit of the possible relief afforded by the construction of the surface-water drains is materially diminished.

The amount pumped per minute of course depends on the intensity of the rainfall at the time; but the volume, roughly, is increased six times the dry-weather flow with moderate rainfall, up to above twelve times with exceptionally heavy falls.

In many districts where storm overflows can be provided (available at all times), it is possible that the water contributed from the roofs and areas might with advantage be carried off by the sewers, but where the safety of a district from flooding depends upon pumping-machinery, power should be given without special legislation, as required at present, to enable Sanitary Authorities to legally exclude all surface-water from the sewers.

The Board's scheme originally intended that such a system should be enforced in their district, but the Local Government Board overruled them on that point. It would appear that no legal power is given to local authorities to exclude rain-water from house drains, although it is done in many districts by arrangement, the only town forming an exception being Reading, where the Corporation works under a special Act.

The three pumping-engines before mentioned are com-

pound horizontal intermediate-receiver jet-condensing engines, each geared to two single-acting ram-pumps. Figs. 1 and 2.

HORIZONTAL ENGINES.

High-pressure cylinders	14 inches diameter.
Low-pressure ditto	24 " "
Stroke	33 inches
Air pumps, single acting	14½ inches diameter.
Ditto stroke	16 inches
Pump plungers	24 inches diameter.
Ditto stroke	5 feet.
Displacement per foot	19·539 gallons.

Each engine is fitted with a fly-wheel 12 feet in diameter and weighing about 8 tons, and is capable of running down to a speed of twelve revolutions per minute.

The cylinder bodies and intermediate receiver are all jacketed with boiler-steam, the jackets being drained into Lancaster steam-traps, and the overflows connected to the boiler feed-pump suctions.

The slide-valves are the ordinary plain pattern, the high-pressure cylinder being fitted with cut-off valve, coupled by a link to governor-gear of the Hartnell type. The low-pressure cylinders are fitted with cut-off valve-gear, adjustable by hand.

The engines are finished with bright cylinder-covers, and valve chest-covers lagged with polished teak, and fitted with feed-pump 3 inches diameter by 3½-inch stroke, drawing from a pocket connected with the hot well.

The necessary valves and by-pass pipes are provided, so that the high-pressure cylinders may be worked direct to the condenser, in the event of a breakdown to the low-pressure engine, and *vice versa.*

The power is transmitted to the bell-cranks by a cast-iron spur-wheel and pinion working an intermediate shaft. The spur-wheel is 11 feet diameter and the pinion 2 ft. 11 in. diameter, the ratio of gearing being 4 to 1. The intermediate shaft, which is 9 inches in diameter, carries a disc, 5 ft. 9 in. diameter, and a movable disc and pin, by means of which the motive power is transmitted to the bell-cranks in the adjoining pump-house by connecting-rods of pitch pine, 18 ft. 4 in. long and 12 in. by 9 in. mid-cross section. The pin on the disc, which is 18 inches in diameter, can be rotated to a limited extent, being secured by six 1¼-inch bolts, allowing the centre of

connection-rod bearing to be brought nearer the centre of disc, and thus shorten the stroke of the pumps, the limits being between 5 feet and 4 feet.

The bell-cranks are cast iron, in one casting, the gudgeon bearing 5¼ inches in diameter.

The pumps are situated immediately below the bell-cranks in the sewage well, on massive cast-iron girders, at a level of 8·00 below Ordnance datum, two similar girders carrying the bell-cranks.

The pumps are single-acting ram-pumps, the rams being 24 inches in diameter, with 5 feet stroke.

The suction-pipes are 24 inches in diameter, the delivery-pipes 21 inches, and fitted at the outlet with cast-iron plug-valve.

Valves: hanging flaps with leather beats and hinges, the suction side of each pump having twelve valves, with clear opening 12¾ inches by 4¼ inches to each, and a lift of 3¼ inches, and a total clear area of 650·16 square inches, the delivery side having six similar valves, but opening 21 inches by 4¼ inches, and a total area of 535·5 inches.

These valves have been very satisfactory, they have given little trouble, and, up to the present, required exceptionally small renewal of leathers.

The original pump cases were in one casting, weighing approximately 14 tons, fitted with inspection and cleaning door, charging pipes, etc.; the delivery chamber, surmounted by an air-vessel, dome-shaped, 5 feet by 3 ft. 2 in. by 2 feet high at centre.

The metal in the pumps is 1 inch thick, and they are ribbed internally.

The maximum pump speed is 150 feet per minute, this giving a speed of 60 revolutions on the engines.

It cannot be said that experience has shown that it was wise to have formed the pumps in one casting. The strains in the ends set up and remaining in the casting when cooling must be very great. As a matter of fact, after about two years' working, signs of weakness began to appear in the pump-ends, one showing a crack reaching from the pump-glands downwards.

It was deemed advisable to take steps to remedy this, and heavy cast-iron brackets or jaws were fixed to the ends with wrought-iron tie-bolts.

In 1896 it was deemed advisable to reduce the maximum speed at which the pumps could be driven as signs of weakness were again apparent, and in 1897 it was decided to take out the whole of the three main pumps, and replace them with new cases, etc.

This was done gradually by the Board's staff in 1898 and 1899.

The new pumps were designed by the Author to fit in, as far as possible, with the existing arrangement of plungers, delivery pipes and suctions.

Each main pump case consists of five principal castings, formed of $1\frac{3}{8}$-inch thick metal, with $1\frac{1}{2}$-inch flanges.

The pump is surmounted by an air-vessel on the delivery-chamber, 5 feet by 2 ft. 6 in. inside diameter, formed of 1-inch metal. The suction chamber is also provided with an air-vessel, 5 ft. 9 in. by 1 ft. 3 in., of $\frac{7}{8}$-inch metal.

The valve plates are secured to a heavy frame, and the valves are very similar to those previously in use, with some slight modifications as to area and lift.

The difference between the pumps will be readily seen from the drawings, Figs. 3 and 4.

In addition to the three engines described, two supplementary engines were provided for pumping effluent water. These pumps are placed in a separate engine room at the end of the range of buildings, the floor being 5 feet below the floor-level of the rest of the premises; they draw from a pump-well 7 feet by 5 ft. 6 in., and 13 feet deep below the level of the floor.

The water passed through the filters is drained to this well, when the level of the river renders it impossible for it to drain out by gravitation, and is pumped up to a high-level channel to sufficient height to flow to the river.

These engines are the ordinary type of duplex pump, being J. B. Worthington and Co's, New York, U.S.A. standard type, and built by that firm.

The valves are the ordinary pattern of valve fitted to this class of pump, there being 18 on the suction, and 18 on the delivery side, each valve being gun-metal $4\frac{5}{8}$ inches in diameter, fitted with brass springs and seats.

Each engine has a pair of cylinders 14 inches in diameter by

15 inches stroke, the pumps being 15 inches in diameter by the same stroke as the engines.

They are non-condensing, and the cylinders are lagged with Leroy's composition, painted imitation wood lagging.

They require a very large amount of steam in working, but fortunately are not often required.

The suction pipes are 12 inches diameter, fitted with foot valves, and the delivery is also 12 inches diameter.

In the summer of 1893, when the Board had determined to proceed with extensions, the Author was instructed to take means to augment the pumping power for sewage, without delay, with the then existing available plant, as some time must necessarily elapse before new engines could be put down. To carry this out the above pumps were connected by means of a suction pipe 21 inches diameter, to the sewage-pump well, a distance of 126 feet. This was laid at the same level as the pumps, and passed by easy bends down on to a benching that had been left in the pump well, at a level of 3·25 below Ordnance datum. The bottom of the suction was fitted with a foot valve, and encased in a rectangular screen 8 ft. by 4 ft. by 3 ft., formed of ½-inch rods placed ¼ inch apart, fixed in a frame of angle-iron 1¼ in. by 1¼ in.

In the supplementary engine-room a suction vessel, 6 feet high by 21 inches diameter, fitted with the usual gauge-glass fittings, was placed where the water is divided between the two engines. Each branch is 12 inches in diameter, and fitted with screw-down cocks, as are the suctions for effluent well, which were altered so that the engines may be quickly arranged to pump either sewage or effluent. Suitable charging pipes, exhaust ejector, etc., are fitted, and the whole arrangement acts well, on the work it is required to do, during exceptional storms.

This addition to the pumping capacity was approximately 4,000,000 gallons per day.

When the works were originally constructed, space was left in the engine-room and pump-room for future additions to the plant, the idea being to add as required two pumping engines similar to those originally put down. The necessary girders had been provided and built into the sewage well.

It was, however, decided to depart from this idea, and to put in engines that would return a higher degree of efficiency,

etc., be more compact, and more powerful. It was accordingly determined to fix the pump on the lower girders, as formerly done, but to carry the engine directly over the pump on the girders provided for the bell-cranks; this arrangement obviated any new foundation, and allowed a new engine-room to be cheaply and conveniently constructed from part of the pump-house, the space in the old engine-room being still available for future extension, or other purposes.

The additions recently finished consist of a three stage expansion vertical pumping engine, Worthington type, having a contract capacity of 12,000,000 gallons per day, but capable of pumping 25 per cent. more if necessary. Also a simple direct coupled centrifugal pumping engine, capable of delivering about 4,500,000 gallons per day 20 feet high.

The new Worthington (Figs. 5 and 6) stands directly on what was purposed to be the bell-crank girders of future No. 5 engine, the pump below being borne by the lower girders.

The pump-cases, with delivery and suction chambers, are of $1\frac{1}{4}$-inch metal throughout, and consist of six castings bolted together with $1\frac{1}{8}$-inch bolts, placed $7\frac{1}{4}$ inches between centres and securely stayed with 2-inch stay-bolts.

The pump-bodies are 10 ft. $9\frac{1}{4}$ in. by 5 ft. by 5 ft., with outer sides curved inwards to a radius of 3 ft. 2 in., the whole of the two sides next the suction and delivery-chambers being occupied by the valve-plates.

The suction-pipe is 36 inches diameter, tapered in the bottom length to 48 inches. The delivery-pipe is 32 inches diameter, bell-mouthed next the delivery-chamber to 36 inches diameter, and terminating in the delivery-channel in a tapered orifice formed in cement, and fitted with plug-valve, etc.

Two air-vessels, each 2 ft. 6 in. diameter and 3 ft. high at centre, were fitted on the delivery-chamber, and two similar vessels on the suction-chamber.

The pump-plungers are hollow cast iron with pump-rod carried right through, working in gun-metal lined sleeves 5 inches deep, $10\frac{3}{4}$ inches above the centre of pump-diaphragm and $4\frac{1}{8}$ inches below.

The valves are very similar to those previously described, the good record given by them influencing the Author in adopting them as against, as was first contemplated, valves with metal hinges.

Each pump-chamber has ten suction-valves, with maximum lift of 5 inches, and the same number on the delivery side.

To obviate any anxiety as to the strength of the lower girders carrying the pumps, two massive cast-iron pillars were placed under the girders, resting on bases of cast-iron 3 feet by 3 ft. 6 in. diameter, 1-inch metal, filled with cement concrete. The columns were afterwards firmly wedged up under the girders.

The engine, as already mentioned, is triple-duplex, but is not fitted with any of the high duty arrangements peculiar to the Worthington type.

VERTICAL WORTHINGTON.

High-pressure cylinders	12 inches diameter.
Intermediate ditto	17 " "
Low-pressure ditto	28 " "
Stroke	36 inches.
Pump-plungers	30 inches diameter.
Ditto stroke	36 inches
Displacement per foot	30·354 gallons.
Contract speed	22·87 revolutions per minute.
Steam pressure (max.)	80 lbs. per square inch.
Clear total area through suction-valves	3330 square inches.
Clear total area through delivery-valves	" "

The whole of the pump and engine work is rendered easy of access by gangways, stairways, etc.

The exhaust-pipes from the low-pressure cylinders pass by easy bends down below the floor to the condenser, which is placed resting on a bracket cast on the suction-pipe.

Two double-acting air-pumps, together with two boiler feed-pumps, with plungers $1\frac{3}{8}$ inches bore by 20 inches stroke, draining from the hot well, are placed on either side.

The air-pumps are 8 inches in diameter, 3 feet stroke, double-acting, with delta-metal pump-rods and gun-metal lined barrels.

The engine-cylinders are jacketed in the bodies.

The steam-valves on the engine are a departure from the usual practice on this class of pump. They are all circular valves, the high and low-pressure cylinders being each fitted with cut-off valves, the cut-off on the high being from 4 to 8, and on the low from 6 to 10, adjustable by hand.

The high and low-pressure valves are placed in the cylinder covers as shown, and are readily accessible. The clearance spaces are considerably diminished by this arrangement.

The valve-gearing is driven from two steel shafts placed below the floor, and receiving motion by links from the piston-rod attached to two beams formed of steel plates 1 inch thick and 13 inches deep at centre, carrying each a heavy balance-weight. The air-pumps and feed-pumps are driven from these beams.

Steam is admitted to the engines through a steam-separator, the drain-pipe of which communicates with a jacket on the low-pressure cylinder steam-pipes, and thence to a water-sack, to which also all the jackets drain. The drainage from this water-sack is admitted from time to time to the pocket from which the feed-pumps draw.

The injection-water is drawn from a well outside, 130 feet distant, fed by water from the effluent filters. This well also feeds the three horizontal engines. A supplemental injection-pipe has been fitted, so that water could be drawn from the sewage-well if at any time the water in the wells should fail.

The engine is lagged throughout with planished steel and nickelled brass bands, and finished in the best manner.

The centrifugal-pump was placed in the new engine-room on the girders opposite the Worthington. It is of the ordinary pattern, with vertical high-speed engine, coupled direct on the pump-spindle, the delivery from the pump being below the level of the floor, forming a neat and compact arrangement. It is fitted with ejectors, valves, lubricating-box, etc., and finished, similar to the Worthington, with planished steel.

The principal dimensions are:—

Cylinder	11½ inches diameter.
Ditto stroke..	9 inches.
Diameter of pump-fan	38 „
Revolutions per minute	255 to 260.
Steam pressure	60 lb.
Diameter of delivery-pipe	15 inches.
Diameter of suction-pipe	15 „

No foot-valve was fitted on the bottom of the suction, but a back-flap was fitted on the delivery at point of discharge.

The pump-suction does not go below $-12 \cdot 00$ feet Ordnance datum, the intention being that the pump should only be used in the event of the water rising over the main pump girders.

It is not assumed that its efficiency or consumption of steam differs from that of ordinary pumps of the kind, a low capital

cost, considering how seldom it will be required, being of more importance than economy in daily work.

No steam trials have been made of this engine, as it is difficult, indeed almost impossible, for arrangements to be made for such. It was, however, properly tested for quantity pumped before delivering from the makers' shops.

Boilers.

For supplying steam to the main engines and the auxiliary plant in the station, consisting altogether of 20 sets of engines, used for pumping, air-compressing, electric lighting, motive power, etc., three boilers were originally provided, and these are sufficient for the work. They are of the ordinary Galloway type, 18 feet long by 6 ft. 6 in. diameter, with two furnaces, 2 ft. 7½ in. diameter, joining one central flue, fitted with 17 Galloway tubes and 4 pockets.

The grate area is 25 superficial feet.

The boilers are set on the Livet system, there being no return-flue below the boiler, the hot gases, on leaving the furnace-flue, flowing along one side and returning by the other to the damper outlet.

Each boiler rests on three cast-iron saddles, with a fire-brick wall dividing the flues.

For convenience in examination this form of setting gives many advantages.

Up till about a year ago the boilers were fed by the feed-pumps on the main engines, with water drawn direct from the hot well, a small Cameron pump being held in reserve in the boiler-house.

On representation, however, from the Boiler Insurance Company, this system was altered, and water taken from the mains of the Southwark and Vauxhall Water Company and used instead of the former supply.

In making the alteration, additional Worthington donkey-feed-pumps were put down, together with storage tanks and other usual accessories.

By the change, however, a certain amount of heat formerly utilised from the hot well was lost, and the boilers were fed practically with cold water. To remedy this, the exhaust steam from a small Worthington supply-pump, situated near

the boiler-house, was passed through a length of 36 feet of 3-inch wrought-iron tubing immersed in the feed-tank, which is about 6 feet square.

By this means the temperature of the water averages throughout the day from 140 to 150 degrees, with a considerable saving in fuel, the outlay on the pipework being trifling.

Each boiler was recently fitted with a Hotchkiss boiler-cleaner, and the sediment drawn off about every half-hour.

The opportunity was taken when putting down the recent extensions of remodelling the system of steam-piping. As originally constructed it was inconvenient, any slight repairs entailing the plant being stopped and the boilers shut off, the whole being without stop-cocks or drainage-traps, except those on the boilers and engines.

The alteration, which forms part of a scheme yet to be perfected, gives many of the advantages of a duplication, and has been found to be convenient in daily working.

SUPERHEATER.

In 1895 the Board authorised the adoption of some system of superheating on the boilers. After considering some of the different types, it was determined to fit a boiler with one of the Schwoerer pattern (Figs. 7 and 8).

Before determining the position the superheating pipes were to occupy, a series of readings were taken in the flues, No. 3 boiler offering facilities for carrying out experiments.

The readings were taken by pyrometers, lent by James Simpson and Co.

It was decided to place the apparatus at the back of the boiler, where the temperature was at all times high. At this point the flue forms a chamber 6 ft. 6 in. by 8 feet high next boiler, and 2 ft. 4 in. deep from the boiler to back wall.

The superheater consists of four rows of cast-iron pipes, each 5 ft. 6 in. long, being connected top and bottom with suitable bends and placed 13 inches apart, centre to centre, resting on a foundation of fire-clay blocks. The pipes are 7 inches in diameter inside; the whole of the outside surface has gills running transverse to the pipes $1\frac{1}{16}$ inch between centres, and projecting $1\frac{3}{4}$ inch, gills somewhat similar, but running longitudinally, being cast in the interior.

In addition, deflecting plates are fitted on spindles centred in each pipe. These plates have the tendency to cause the steam to descend or ascend in a spiral direction, ensuring that it is thrown into contact with the hot metal.

The whole of the apparatus was fixed by the Board's employees, and is connected to the piping with screw-cocks, and fitted with mercury thermometer pockets, relief and drain valves.

The arrangement is compact, and has up to the present given no trouble at the joints or otherwise. No difference is made to the stoking or conduct of the daily work in the boiler house between the boiler fitted and those not fitted. To determine the amount of superheat that might be obtained in ordinary daily working, observations over many weeks were taken. Some of these are given below.

AMOUNT OF SUPERHEAT IN STEAM LEAVING SUPERHEATER.

Boiler Evaporating Average of 3000 *lbs. of Water per Hour.*

No.	Time. 9 a.m.	Time. Noon.	Time. 3 p.m.	Average.
1	115°	118°	122°	118·3°
2	83°	105°	94°	94·0°
3	130°	163°	161°	151·3°
4	120°	165°	161°	148·7°
5	131°	133°	130°	131·3°
6	103°	128°	144°	125·0°
7	92°	144°	171°	135·7°

Boiler Evaporating Average of 1500 *lbs. of Water per Hour.*

No.	Time. 9 a.m.	Time. Noon.	Time. 3 p.m.	Average.
1	25°	40°	54°	39·7°
2	26°	31°	43°	33·3°
3	47°	47°	42°	45·3°
4	37°	48°	68°	51·0°

In the first, the boiler was set so as to deliver a fair proportion of steam, evaporating about 3000 lbs. of water per hour.

It will be seen that the amount of superheat depends on the state of the fire, but altogether it was fairly constant.

In the second, the boiler was set to deliver a small amount of steam, being worked in common with the other boilers as in daily work.

It will be noticed the amount of superheat did not fall below 25° at any time.

It should be mentioned that the supply of steam taken from the boiler was not constant, but irregular, to suit requirements of the station.

Trials.

Since the superheater was fixed, a series of tests have been made on the different types of pumping engines, so that comparison can be made between their performances with superheated and unsuperheated steam. The requirements of the station make it inconvenient to have certain departments of the work laid off for a longer period than 12 hours, as would have been required in running trials on coal consumption to be of any practical value.

The engines tested were selected from those described in this paper, and were not in any way specially prepared for tests or overhauled; all were in fairly good condition.

The first trials were made on Engine No. 9, being one of the Worthington low-duty pumps already described.

The steam before reaching the cylinders had to pass through a length of 140 feet of steam pipe, boiler stop-valve to engine stop-valve. The whole length is coated with Leroy's non-conducting composition, but passes across and through passages where it was subjected to cold currents of air; a small portion of the pipe was exposed to the external air. The pipe is also too small to allow the engines to develop their full power.

It was not expected that under the circumstances a large amount of superheat in the steam would be available at the engine.

The class of pumping engine to which the engine in question belongs are heavy in steam consumption, although convenient for many purposes, and it was expected that the consumption of steam would be about 100 lbs. per indicated horse-power. The efficiency would also be low, owing to the small lift.

It may be here mentioned that although in most cases the consumption of steam was measured on the indicated horse-power, the object of the trials was to measure the amount of

steam required on the useful work alone—that is, in water lifted. The amount of steam per pump horse-power is therefore given in every case.

TRIALS OF WORTHINGTON LOW DUTY PUMPING ENGINE. No. 9 (NON-CONDENSING).

	Saturated Steam.	Superheated Steam.
Speed, double strokes, per minute	53·05	60·04
Head, including suction, feet	13·00	14·1
Pump horse-power	7·94	9·79
Indicated horse-power	23·35	29·12
Duration of trial, hours	5	5
Feed per P.H.P. per hour, lbs.	313	224·8
Feed per I.H.P. do.	106	75·6
Mechanical efficiency, per cent.	34	33·6
Average boiler pressure, lbs. per square inch	60	60
Superheat at boiler, degrees Fah.	—	124
Percentage of gain in steam per P.H.P.	—	28·2

In the above cases, in the Author's opinion, the benefit derived was principally due to the very dry steam used, the amount of superheat reaching the engine being small.

The horse-power developed by the superheated steam under conditions exactly similar to the trial on saturated steam was greater, the engine running 7 double strokes faster than with saturated steam. In both cases the steam stop-valve was full open.

TRIALS ON HORIZONTAL GEARED PUMPING ENGINE.

	Saturated Steam. 1.	Superheated Steam. 2.	Superheated Steam. 3.
Speed, revolutions per minute	60·2	59·54	61·9
Head, including suction, feet	38·5	38·50	38·0
Pump horse-power	34·2	33·92	105·5
Indicated horse-power	53·78	51·92	—
Duration of trial, hours	5	5	5
Feed per P.H.P. per hour, lbs.	33·7	31·42	26·7
Feed per I.H.P. do.	21·4	20·5	—
Mechanical efficiency	63·5	65·3	—
Average boiler pressure, lbs. per square inch	53	53	53
Vacuum, inches	27·00	27·00	26·3
Superheat at boiler, degrees Fah.	—	101·5	141·7
Gain per cent. per P.H.P.	—	6·76	20·77

Note.—Feed includes jacket-water, etc.

In the above, on trial No. 2, as the engine was not capable of taking a fair draught of steam from the boiler, and the steam had to pass along 62 feet of pipe varying in diameter from 5 to 7 inches, in addition 61 feet of pipe was in communication filled with steam, but not in circulation, the superheat was principally lost in the steam-piping before reaching the engine, and was approximately 30° only. The gain shown was, however, 6·76 per cent. on the pump horse-power in No. 3.

Three engines identical and similar in every respect were run, and the boiler worked to supply steam just as required. The superheat at the boiler did not vary 10° during the whole run, the gain in this case being 20·77 per cent.

TRIAL ON VERTICAL WORTHINGTON.

	Saturated Steam.	Superheated Steam.	Superheated Steam.
Speed, revolutions per minute	28·48	28·4	29·64
Total head, including suction, feet	35·25	35·50	36·5
Pump horse-power	110·4	111·5	119·41
Indicated horse-power	126·4	—	—
Duration of trial, hours	12	12	4
Feed per P.H.P. per hour, lbs.	19·55	17·99	17·60
Feed per I.H.P. do.	17·00	—	—
Mechanical efficiency	87·4	—	—
Vacuum, inches	27·75	27·75	27·75
Boiler pressure, lbs. per square inch	75	75	75
Superheat at boiler, degrees	—	100	104
Gain per cent per P.H.P.	—	7·97	9·97

The distance from superheater to stop-valve of engine was 92 feet. In the above the jacket-water is not included.

In all the above trials the Author has given the consumption of steam only, as any saving, leaving out of consideration the reduced amount of drainage from steam-traps, etc., of course represented a direct saving in coal, equal to the amount of coal that would be required to evaporate the difference in water consumption by superheated and saturated steam, unless the superheater, by abstracting heat in the flue, impairs the evaporative efficiency of the boilers. From trials made in ordinary working, the Author has not found that any difference can be detected in working.

When the trials above mentioned were made, the boiler

and apparatus had been in constant work from six to eight weeks without the boiler having been washed out or the flues opened to clean the dust out of the superheater, and the results show, therefore, what can be got in actual work, and not by specially prepared test runs.

The whole of the above engine-plant was supplied by James Simpson and Co., Pimlico, and erected by them, with the exception of the centrifugal pumping-engine and piping, steam-piping, superheater and duplicate suction for effluent pumps, pump-cases, all of which (in addition to the builder's work in the new engine-room, etc.) were erected by the Board's employees.

The Members of the Association held their Annual Dinner at the Criterion Restaurant, on Thursday evening, July 26. The President, Mr. C. H. Lowe, occupied the Chair and was supported by several distinguished guests.

The proceedings closed at noon on the second day. Two parties were formed: one to proceed to Woolwich to inspect the Royal Arsenal, and the second to visit the Staines Reservoirs. The first party on arrival at Woolwich proceeded to the Mortar Hotel, and there partook of luncheon at the invitation of the President. After lunch the party was divided into sections, each under a guide, and taken through as much of the vast extent of works as time would permit.

The second party was received on arrival at Staines by Mr. Basil Ellis, on behalf of Messrs. J. Aird and Sons. Luncheon had been kindly provided at the Pack Horse Hotel, and after this had been partaken of the Members took their seats in a "contractors' train," and were taken round the whole of the works. A full description of these works will be found in the Appendix to this volume.

On the third day the Members left Victoria by special train for Chatham at the kind invitation of Messrs. Aveling and Porter. On arrival at the Dockyard the party was met by Staff-Captain Douglas, R.N., and Mr. W. J. Clarke, who throughout the day were most courteous and indefatigable guides. Only a small portion of the yard could be seen in the time. The Torpedo Depôt was found especially interesting. Mr. Fielder, Fleet Engineer, explained the general construction of the Whitehead Torpedo, and the propeller action was practically illustrated for the benefit of the Members.

Commander Daintree, R.N., received the Members on board H.M.S. 'Amphitrite,'—a first-class cruiser. This fine vessel was thoroughly inspected.

Reaching the 'Thunderbolt' pier, the party embarked on the river steamer 'Lady Margaret.' An excellent luncheon was heartily enjoyed whilst steaming down the Medway, a cooling breeze rendering the atmospheric conditions ideal for a river trip. Mr. Stephen Aveling, who is a most ardent antiquary, gave the Members a very interesting account of Upnor Castle and its associations.

Passing Queensborough, the trip was extended to the Nore Light, and it was then necessary to return.

PLATE I.

ERY AT RICHMOND.

EY.

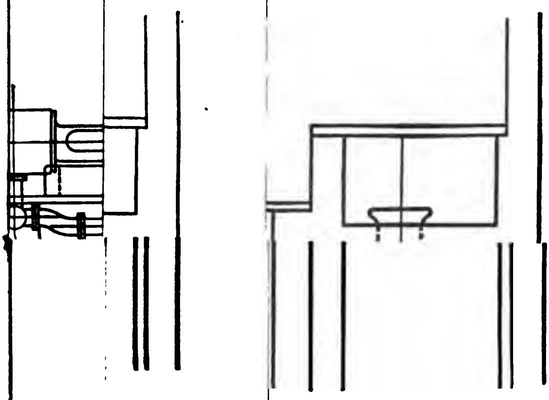
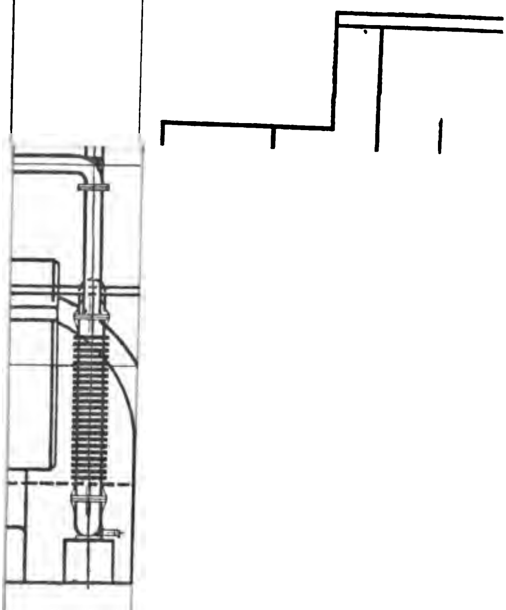


PLATE II.

INERY AT RICHMOND.

W. FAIRLEY.



APPENDIX.

THE ORPHAN FUND

OF

THE INCORPORATED ASSOCIATION OF MUNICIPAL AND COUNTY ENGINEERS.

THE first General Meeting of the Subscribers to the above Fund was held at the Westminster Town Hall on Thursday, July 19, 1900, at 10 a.m., Mr. WILLIAM HARPUR, President of the Association, in the Chair.

Mr. O. CLAUDE ROBSON, the Honorary Secretary, read the following Report with regard to the proceedings of the Committee during the preceding year, viz.:—

"Gentlemen,—Upon this occasion of the presentation of the first Annual Report of the Orphan Fund of the Association of Municipal and County Engineers it may perhaps be of interest to briefly chronicle the history of the initiation of the scheme.

"The desirability of instituting a Benevolent Fund in connection with the Association, was considered by the Council at the instigation of some of its Members upwards of four years since, and endeavours were then made to inaugurate a fund for the relief of the necessitous children of deceased Members of the Association. Notwithstanding the efforts then made but little or no response came to the appeal, and the question lapsed into a somewhat moribund condition until the latter part of 1898.

"The necessity for some such fund was then taken up in a generous and energetic manner by the Editor of the *Surveyor*, with the result that in about three months subscriptions and donations amounting to 50*l.* were received. This amount was gradually increased, until at the last Annual Meeting at Cardiff the amount of the Fund was raised to 183*l.* 6*s.*, which included the handsome donation of 105*l.* from Mr. John Parker of Nottingham. It was then thought desirable that a Provisional Committee for the government of the Fund should be appointed, and this was effected by the Council of the Association in February 1900, when a Committee and Officers were temporarily appointed pending the adoption of Rules, together with the official appointment of a Committee and Officers at this meeting.

"The Provisional Committee referred to have duly framed rules and regulations for the governing of the Fund, which they now present to the Subscribers for consideration and confirmation.

"The intention is to utilise the Fund for the benefit of orphans of deceased Members rather than institute a general Benevolent Fund, for which purpose there is extreme doubt if a sufficient amount could be at any time collected.

"No call has hitherto been made upon the funds of the Charity, which at the present date amount to 290*l.* 0*s.* 9*d.* Of this sum 250*l.* has been invested in London and North Western Railway Stock in the names of the Trustees before mentioned, whilst the sum of 39*l.* 8*s.* remains as a current or drawing account, as set forth in accompanying Balance Sheet.

"The number of subscribers is thirty-four, representing a total of 44*l.* 6*s.* per annum, whilst donations have been received from fifty-three donors, providing a total of 237*l.* 2*s.*

"It is earnestly hoped that from a muster roll of nearly 1000 Members of the Association the number of Subscribers in the future may be augmented, so that a reliable income may be established for any necessitous calls, whilst the present invested Capital remains intact.

"The Subscriptions already paid will extend to December 31, 1900, when the first Official Financial year under the auspices of the regular elected Committee will commence.

"May the Fund, thus started by the generous efforts of the Editor of the *Surveyor* and others, develop into an institution that will be an earnest of the charitable disposition of the Members of the Association, and a strong and useful medium of assistance to the necessitous orphans of Municipal Engineers when occasion arises."

BALANCE SHEET.

Dr.	£ s. d.	Cr.	£ s. d.
Total amount of Donations .	237 1 9	Purchase of L. & N.W.R. Stock	249 14 9
" Subscriptions	46 8 0	Postages, &c.	18 0
Interest on £250 placed on deposit	3 4 4	Balance at Bank	39 8 9
Interest on L & N.W.R. Stock	3 6 8		
	£290 0 9		£290 0 9

Examined and found correct (Signed) CHARLES JONES.
THOMAS HENRY YABBICOM.

It was proposed by Mr. BARBER, seconded by Mr. LOWE, and carried unanimously, That such Report be approved and adopted.

The Honorary Secretary then read the proposed Rules and Regulations for the governing of the Fund.

It was proposed by Mr. LOWE, seconded by Mr. MAWBEY, and carried unanimously, That the draft rules as submitted be approved and adopted, and that a copy of same be forwarded to all Members of the Association.

The election of Members of the Committee by Ballot was then proceeded with, when the following Subscribers were declared to be elected as Members of the Committee for the ensuing year, viz.:—

C. H. LOWE, M. Inst. C.E.,
President of the Association (*ex-officio*).

LEWIS ANGELL, M. Inst. C.E.	C. JONES, M. Inst. C.E.
J. PATTEN BARBER, M. Inst. C.E.	F. J. C. MAY, M. Inst. C.E.
J. W. COCKRILL, M. Inst. C.E.	S. S. PLATT, M. Inst. C.E.
A. CREER, A. M. Inst. C.E.	E. J. SILCOCK, A. M. Inst. C.E.
W. HARPUR, M. Inst. C.E.	R. J. THOMAS, A. M. Inst. C.E.
E. PURNELL HOOLEY, A. M. Inst. C.E.	E. WILLIS, F. S. I.

It was proposed by Mr. JONES, seconded by Mr. HARPUR and carried unanimously, That Mr. ROBSON be elected as Honorary Secretary and Honorary Treasurer for the ensuing year.

It was proposed by Mr. BARBER, seconded by Mr. THOMAS and carried unanimously, That the following Subscribers be elected as Trustees, viz. J. T. EAYRS, M. Inst. C.E., O. CLAUDE ROBSON, M. Inst. C.E., and T. H. YABBICOM, M. Inst. C.E.

It was proposed by Mr. JONES, seconded by Mr. HARPUR and carried unanimously, That a Vote of Thanks be accorded to the Editor of the *Surveyor* and the Honorary Secretary for services rendered to the Fund during the preceding year.

The Meeting was then adjourned until the next General Meeting to be held in accordance with Rule 19 of the Fund.

RULES.

Name.

1. This Institution shall be called "The Orphan Fund of the Incorporated Association of Municipal and County Engineers."

Object.

2. The object of the Orphan Fund is to afford assistance to necessitous orphans of members and graduates of the Incorporated Association of Municipal and County Engineers, who have paid their subscription for 5 years consecutively at least.

Capital and Income.

3. The Fund shall be supported by means of Donations and Bequests, and Annual Subscriptions of not less than ten shillings.

4. All donations and bequests received or promised prior to January 1st, 1901, shall be considered as Capital, and shall be invested in the names of the Trustees of the Orphan Fund of the Incorporated Association of Municipal and County Engineers, in such Stocks or Funds as are permitted by the Trustee Act, 1893, or any amendment thereof, and no part of such funds so invested shall be withdrawn from Capital, except by a resolution authorising such withdrawal, passed at a General Meeting of the contributors specially convened for the purpose.

5. All donations and bequests received or promised subsequent to January 1st, 1901, shall, unless otherwise directed by the donors, be invested by the Trustees, as provided in Rule 4, or shall be available for affording assistance to the persons eligible to receive such assistance, subject to the limitation contained in Rule 8.

6. All annual subscriptions and all dividends and interest arising from capital shall be considered as income, and shall be applicable to the payment of grants and the assistance of applicants, and to the payment of necessary charges and expenses.

7. The accumulation of income, unexpended donations, and bequests (if any) which may arise from year to year, after payment of all the grants and other charges and liabilities of the Fund, may, in the discretion of the Committee of Management, be invested as provided in Rule 4.

8. The Committee of Management may, out of donations, bequests and income, apply in assistance in each year a sum not exceeding in amount the income of the preceding year together with the unexpended balance accruing from previous year or years; and it shall be competent for any General Meeting to authorise the application of a larger sum.

Privileges of Contributors.

9. The following contributors to the Fund shall be entitled to vote at all General and Extraordinary General Meetings, and for the election of the Committee by ballot, as follows:

All subscribers (being Members of the Association) of not less than ten shillings shall have one vote for each year so subscribed, and donors (also being Members of the Association) of not less than 5*l.* in one payment shall have one life vote, but no subscriber or donor shall have more than one vote.

10. Votes may be recorded either personally or by proxy upon all questions, excepting the election of the Committee of Management, and for such election they may be recorded by delivery to the Scrutineers, either personally or through the Hon. Secretary, of a list issued by the Committee under Rule 12.

11. Annual Subscription shall be payable in advance on the 1st of January in each year, and no subscriber whose subscription is in arrear for one year shall be entitled to any privileges as to voting or otherwise.

Committee of Management.

12. For conducting the affairs of the Fund there shall be a "Committee of Management," consisting of the President, for the time being, of the Incorporated Association of Municipal and County Engineers as Chairman, the three Trustees, Hon. Secretary and Hon. Treasurer, and twelve ordinary members who are subscribers to the Fund, elected in accordance with Rule 10; three to form a quorum. The Committee so elected to hold office for three years, four of the ordinary members retiring annually in rotation, but be eligible for re-election. Those retiring in the first and second years shall be determined by lot by the members of the Committee.

The Committee shall before each Annual General Meeting prepare a list of persons to fill the vacancies on the Committee for the ensuing year. Such list shall be forwarded to each subscriber and donor to the Fund who is a member of the Association, one week at least before the Annual Meeting; and each subscriber and donor shall be at liberty to vote for the persons nominated, or to substitute the name or names of any other subscriber or donor who is a member of the

Association to fill the office; but the number or names selected or substituted must not in any case exceed the number to be elected.

In the event of the death, resignation, or inability to act, of any of the Committee of Management, the Committee shall elect another member to supply the vacancy until the next Annual General Meeting.

13. The Committee shall meet from time to time to receive from the Honorary Secretary a statement of accounts, and make all payments by cheque, signed by at least two members of such Committee and countersigned by the Honorary Secretary.

14. The Committee of Management shall have full power to make grants and afford assistance to any necessitous orphans of members and graduates of the Incorporated Association of Municipal and County Engineers. The fact of having been a contributor to the Fund shall not in any case constitute a claim to participate in it, but the cases of those who have been contributors to the Fund shall receive prior consideration, other circumstances being equal.

15. The Committee of Management may for the conduct of the affairs of the Fund from time to time make such regulations, not being inconsistent with these Rules, as they shall deem expedient.

16. The mode of application for grants and assistance, and the nature of the recommendations to be required in support thereof, the qualifications and merits of the applicants, the amounts of the grants in individual cases, and also the purposes to which such grants shall be applied, and the advisability of their renewal, shall in every case be left to the determination of the Committee of Management.

17. The Committee of Management shall have power to make investments in the names of the Trustees.

18. The Committee of Management shall not make any grants or payments by which the donations, bequests, or income of future years shall be anticipated or appropriated.

Meetings.

19. A General Meeting of the contributors to the Fund shall be annually held on one of the days appointed for a Meeting of the Incorporated Association of Municipal and County Engineers, and at such meetings a report of the Committee shall be presented, containing the names of all the contributors to the Fund, a statement of the number and amounts of all the grants made and assistance afforded during the past year up to and inclusive of the 31st day of December, and of the general state of the Fund on the last-named day; but it shall not be necessary to publish the names of the applicants for and the recipients of, the assistance afforded by the Fund; and the

accounts shall be produced, certified by the Auditors of the Incorporated Association of Municipal and County Engineers.

20. An Extraordinary General Meeting may be called as often as the Committee of Management shall deem necessary, and also whenever the President of the Association of Municipal and County Engineers shall be required in writing to do so by twenty contributors to the Fund, specifying the object for which they desire such meeting to be called; but no business shall be transacted at such meeting, or at any adjourned meeting thereof, other than that specified in the requisition.

21. The presence of at least ten contributors to the Fund shall be necessary for the transaction of business at either a General or an Extraordinary General Meeting; and if that number be not present within half an hour of the time appointed, the contributors present may adjourn the meeting.

22. All questions introduced at any General or Extraordinary General Meeting shall be decided by the votes recorded in accordance with Rule 10, and should the votes be equal, the Chairman may give a casting vote, provided always that no motion for altering the objects of the Fund, or for diverting any portion of the funds from the purposes herein specified, be adopted, unless at an Extraordinary General Meeting summoned for the express object of discussing such motion, and unless the same be carried by a majority of at least three-fourths of the votes given at such meeting.

Honorary Secretary and Honorary Treasurer.

23. The Honorary Secretary and Honorary Treasurer to the Fund shall be appointed each year at the Annual General Meeting, and these officers shall be *ex officio* members of the Committee of Management.

Auditors.

24. The Auditors of the Incorporated Association of Municipal and County Engineers shall be the Auditors of the Fund.

25. The banking account of the Fund shall be kept at a bank in the metropolis to be approved by the Committee, and the first bankers shall be the London and South Western Bank, Brondesbury Branch.

Trustees.

26. Three Trustees shall be appointed at the first Annual General Meeting in whose name shall be invested all the property of the Fund, except such as shall be from time to time in the hands of the Committee; and when any vacancy arises it shall be filled up by a

General Meeting to be specially convened for the purpose, and the remaining Trustees shall immediately transfer all property and funds in the names of themselves and the new Trustees.

27. Each of the said Trustees shall be chargeable only for such moneys, funds, and securities as he shall actually receive, notwithstanding his signing any receipt for the sake of conformity, and shall be answerable and accountable only for his own acts, receipts, neglects, or defaults, and not for those of the other Trustees, nor for any banker, broker, or other person with whom any trust moneys or securities may be deposited, nor for the insufficiency or deficiency of the said moneys, funds or securities, nor for any other loss, unless the same shall happen through his own wilful neglect or default.

28. The Trustees shall from time to time pay over the dividends, interest and annual income arising from the property of or belonging to the Fund, to the Committee of Management for the time being, or permit the same to be received by them.

New Rules and Alterations of Existing Rules.

29. Any new Rules may be made and any of the foregoing Rules may be altered, amended, or revoked by a General Meeting, provided that the nature and effect of the proposed new Rules or alterations, amendment or repeal, be distinctly specified in the advertisement or notices convening the meeting, and that the enactment, alteration, amendment or repeal be determined upon by a majority of at least three-fourths of the votes of those present, or voting by proxy, at such meeting; and no such enactment, alteration, amendment or repeal, shall be valid until confirmed by a like majority at another General Meeting specially convened for that purpose, such last-named General Meeting to be held not more than two months, nor less than one month, after the first-named meeting.

STAINES RESERVOIRS WORKS.

FRIDAY, JULY 20TH, 1900.

THESE works, which are being constructed by a Joint Committee of nine members, three from each of the Boards of the West Middlesex, Grand Junction, and New River Waterworks Companies, are near Staines. The intake from the Thames is situated in Buckinghamshire on the left bank of the river, about 300 yards above Bell Weir. At this point sluices and a sluicehouse are constructed, the intake being protected by screens to prevent leaves and other floating matter from entering the conduit. The first length of the conduit for about 350 yards is covered, as required by the Act of Parliament, and, running from the intake in a north-easterly direction, is carried in two steel syphons under the Colnebrook, after passing which it becomes an open conduit, the sides and bottom being formed of Portland cement concrete made in the proportion of about 4½ to 1. The conduit passes under the Great Western and London and South Western Railways in double tunnel, and under the Wyrardisbury River through steel syphons, crosses Staines Moor, is syphoned under the River Colne, and runs to the pumping station, situated near the Billet Bridge which carries the London Road over the River Ash.

The pumping machinery will consist of five triple-expansion surface-condensing Worthington pumping engines (one being a spare engine), each capable of delivering 16 million gallons of water daily into the reservoirs. Steam will be provided by six Babcock and Wilcox boilers (one spare), the working pressure being 150 lbs. per square inch. The water will be delivered into the reservoirs through two riveted steel mains, each 6 feet 4 inches diameter, joining into a steel pipe 7 ft. 10½ in. internal diameter near the reservoir, from which branch pipes of the same diameter will be taken through tunnels constructed in the clay, and connected to a water tower near the corner of each reservoir, where the western and central embankments join. The tunnels and water towers are massive constructions of Portland cement concrete, the former lined, and the latter faced with blue bricks.

The stand-pipes for discharging water from the reservoirs will be of cast iron, 5 feet internal diameter, having 48-in. and 36-in. sluice valves, with bell-mouth bends fitted to them, to enable the water to be drawn off at any desired level. These valves will be worked from a platform at the top of each of the water towers, the gearing being enclosed in a suitable building. From the bottom of the stand-pipe of each reservoir a cast-iron pipe 4 feet diameter will convey the water through the tunnel and across the New Stanwell Road to a basin 50 feet in diameter, in which a weir will be constructed, for the purpose of aeration, and over which the water will be delivered into the conduit, which will rejoin the main conduit a little to the east of the pumping station. Proper sluices will be provided for regulating the supply into and from the reservoirs.

The reservoirs Nos. 1 and 1A are about 1¼ miles long by five-eighths of a mile wide at their northern end, and nearly a mile wide at their southern end. The embankments vary in height from 21 feet to 39 feet, and are formed of material excavated from the interior of the reservoirs, the excavation just balancing the banks to prevent the material running to spoil. The slopes of the embankments are three to one inside, and two to one outside the reservoirs. In the centre of each bank a puddle wall is constructed 6 feet thick at the top, 7 feet at the ground level, and tapering down to 4 feet, where it joins the London clay into which it is securely toothed. This construction, for which this part of the Thames Valley is favourably adapted, will make the reservoirs perfectly water-tight. The inside slopes of the reservoirs are lined with concrete 5 inches thick for a vertical depth of 15 feet, so as to resist any wave action which may take place in so large a sheet of water. The average depth of the water in the reservoirs is about 30 feet, and their content is 3300 million gallons. The aqueduct and reservoirs will be guarded on all sides by unclimbable wrought-iron fencing, and the embankments will be sown with grass.

After leaving the pumping station, the conduit is reduced in section, and runs through the Billet Bridge by the side of Shortwood Common, under the London and South Western Railway, and across the fields, passes under the Staines and Kingston Road, the line of which it generally follows until it arrives at Sunbury Cross. From this point the aqueduct runs in a north-easterly direction, along the north side of the East London Waterworks at Hanworth, after which it bends to the south, passes under the Thames Valley branch of the London and South Western Railway, and is finally joined to a reservoir of about 30 million gallons capacity, which is constructed to the east of Kempton Park. The New River Company will take its water from the aqueduct between the East London Waterworks and the Thames

Valley Line. The West Middlesex and Grand Junction Companies will receive their proportion of the water from the Kempton Park reservoir just alluded to. Proper measuring apparatus of special construction will be provided on the aqueduct leading from the Thames to the pumping station, on the smaller aqueduct from Billet Bridge to Hampton, and at the outlet to each of the companies. Venturi meters will be fitted in the 7 ft. 10½ in. pumping mains leading to the reservoir and in the 48-inch mains leading from the reservoir. Automatic records of the water passing down the aqueducts, of the level of the water in the aqueducts, and of the water passing through the several Venturi and other gauges will be kept, and in most cases will be repeated in the engine house. The capital provided under the Staines Reservoirs Act, 1896 and 1898, is 1,250,000*l.* The works have been designed, and are being carried out for the Joint Committee by Messrs. Walter Hunter and Reginald E. Middleton, M.M. Inst. C.E., MM.I.Mech. E., of Westminster, the contract being entrusted to Messrs. John Aird and Sons, of Lambeth. Messrs. James Simpson and Co., London, are constructing the pumping engines; Messrs. Thomas Piggott and Co., Birmingham, the steel pipes; and Mr. G. Kent the gauges.

The following statement shows the progress which has been made in the works:—

INTAKE.—The concrete foundation for down-stream wall in front of cottages has been put in, and the work at sluice house, gas producer house, and cottages is going on satisfactorily.

SMALL AQUEDUCT:—			Lin. Yards.
Invert. Length laid . .	Section No. 1	2100	
	Section No. 3	2376	
		——	4476
Side Walls. Length built to full height each side . .	Section No. 1	2075	
	Section No. 3	2024	
		——	4099
Excavations. To full depth for length of . . .	Section No. 1	2240	
	Section No. 3	2662	
		——	4902
Rendering. Length of side walls rendered each side . .	Section No. 1	735	
	Section No. 3	814	
		——	1549
Length of invert rendered .	Section No. 1	680	
	Section No. 3	0	
		——	680

Coping. Length laid on each side wall . . .			Lin. Feet.
	Section No. 1	4574	
	Section No. 3	3108	
			7682

SYPHONS.—Steel syphons at Colne River laid, and the concrete to surround them is almost complete. Dredging still going on for the Wraysbury River steel syphons.

Work going on at stream; syphons at Shortwood Allotments, White House, and near Hanworth Road.

RAILWAY CROSSINGS.—Syphon under London and South Western Railway at Shortwood Common is complete.

BRIDGES.—Work proceeding at Spelthorne cross roads, and Hanworth road bridges, and also at several accommodation bridges.

48-INCH PIPES LAID (12-foot lengths).	Lengths laid.
Colne River intake	31
Wraysbury River intake	17
Grand Junction Company's branch . . .	231
West Middlesex Company's branch . .	97

			Lin. Yds.
FENCING.—Length erected .	Section No. 1	11,400	
	Section No. 2	6,600	
	Section No. 3	9,605	
			27,605

PUMPING STATION.—Work going on at all the buildings. The iron-work of roof of the boiler-house is being fixed.

SEWER CULVERTS, BILLET BRIDGE.—Part of the arch has been turned and a commencement made to lay in the culvert the 12-inch and 4-inch iron pipes.

RESERVOIRS 1 AND 1A.

TUNNEL No. 1.—Finished for length of 227 feet from centre of tower and invert and side walls built for a further length of 35 feet.

MANHOLE No. 1.—Concrete of circular walls is raised 16 feet above top of tunnel.

TOWER No. 1A.—Is now built to height of about 67 feet above foundation.

TUNNEL No. 1A.—Finished for length of 192 feet from centre of tower.

MANHOLE No. 1A.—Concrete of circular walls is raised 5 feet above top of tunnel.

		Lineal Yards.	About Miles.
PUDDLE WALL.—Length raised from 8 feet to 36 feet high (whole length)		7472	4¼
Part of which is to full height		2240	1¼
EMBANKMENT.—To full height for length of		2200	1¼
Do.	Length of outside slopes soiled	2240	1¼
Do.	Length concreted	836	½
Do.	Length concreted with alternate squares of concrete	88	
Do.	Length concreted with every fourth square only	154	
Do.	Length of roadway formed on top	363	

HAMPTON RESERVOIR.

Excavation, Banking, and Puddling Work going on. Concrete work also going on at the Grand Junction Company's Outlet Works.

STEAM NAVVIES.—There are six steam navvies getting banking and one getting clay for puddle at Reservoirs 1 and 1A, two pug mills grinding clay at Reservoirs 1 and 1A, and one grinding clay at Hampton Reservoir.

STATISTICAL RETURNS

On the following subjects lie at the Offices of the Association, 11 Victoria Street, Westminster, S.W. Those marked thus * are in duplicate, and can be borrowed for perusal by Members on application to the Secretary. Those *not* marked * can only be inspected at the Offices.

(Members are requested, when sending statistics, to kindly send them in duplicate if possible.)

DISPOSAL OF LIQUID NIGHT SOIL.

*Information from various towns. Compiled by G. T. Lynam, A.M. Inst. C.E., Burton-on-Trent. 1899.

DRAINAGE (HOUSE).

Information from 31 towns. Compiled by J. Atkinson, A.M. Inst. C.E., Stockport. 1894.

FIRE BRIGADES.

*Information from various towns. Compiled by G. T. Lynam, A.M. Inst. C.E., Burton-on-Trent. 1899.

HORSES (COST OF KEEPING).

Information from 29 towns. Compiled by M. Petree, A.M. Inst. C.E., Grimsby. 1896.

LIGHTING (ELECTRIC).

Information from 38 towns. Compiled by J. W. Brown, A.M. Inst. C.E., West Hartlepool. 1894.

Information from 88 towns and 10 London vestries. Compiled by J. W. Cockrill, A.M. Inst. C.E., Great Yarmouth. 1891.

Information from 58 towns. Compiled by W. A. Davies, A.M. Inst. C.E., Aston Manor. 1893.

Information from 36 towns. Compiled by E. J. Silcock, A.M. Inst. C.E., King's Lynn. 1896.

LIGHTING (GAS).

Information from various boroughs. Compiled by J. W. Bradley, A.M. Inst. C.E., Nelson. 1895.

Information from 38 districts as to undertakings in the hands of Local Authorities. Compiled by P. Ross, A.M. Inst. C.E., North Bierley. 1896.

LIGHTING (PUBLIC STREET).

Information from 21 towns. Compiled by A. H. Campbell, A.M. Inst. C.E., Canterbury. 1895.

Information from 54 towns. Compiled by C. C. Smith, Dalton-in-Furness. 1892.

PAVEMENTS (COMPARISON OF LIFE AND COST OF GRANITE AND GRITSTONE).

Information from 33 towns. Compiled by C. F. Wike, M. Inst. C.E., Sheffield. 1890.

PAVEMENTS (TAR MACADAM).

Information from 19 towns. Compiled by E. A. Stickland, A.M. Inst. C.E., Windsor. 1897.

PRIVATE STREET IMPROVEMENTS (CONSTRUCTION OF WORKS OF).

Information from 49 towns. Compiled by W. J. Newton, A.M. Inst. C.E., Accrington. 1892.

PUBLIC BATHS AND WASHHOUSES.

*Information from 44 towns. Compiled by P. Edinger, Frome. 1897.

REFUSE (COLLECTION OF).

Information from 89 towns. Compiled by J. Price, A.M. Inst. C.E., Toxteth Park. 1891.

REFUSE (DESTRUCTORS).

Information from 36 towns. Compiled by W. Brooke, A.M. Inst. C.E., Richmond. 1885.

Information from various towns and districts. Compiled by J. Gammage, Borough Surveyor, Dudley. 1899.

REFUSE (DISPOSAL OF).

Information from 39 towns. Compiled by J. Price, A.M. Inst. C.E., Toxteth Park. 1896.

REFUSE (REMOVAL OF).

Information from 87 towns. Compiled by C. R. Fortune, Bath. 1886.

ROADS (MAINTENANCE OF MAIN IN NON-COUNTY BOROUGHS).

Information from 83 towns. Compiled by W. H. Smith, A.M. Inst. C.E., Carlisle. 1894.

Roads (Paving of Main).

Information from principal towns of Great Britain. Compiled by H. Richardson, A.M. Inst. C.E., Aston Manor. 1899.

Roads (Steam Rolling of).

Information from 42 towns. Compiled by A. W. Parry, A.M. Inst. C.E., Reading.

Roads (Watering of).

Information from 65 towns. Compiled by W. Dawson, A.M. Inst. C.E., Leyton. 1891.

Scavenging (Street).

Information from 87 towns. Compiled by C. R. Fortune, Bath. 1886.

Sewage (Disposal of).

Information from 53 towns. Compiled by J. H. Cox, M. Inst. C.E., Bradford. 1892.

*Information from 172 towns. Compiled by J. W. Cockrill, M. Inst. C.E. 1900.

Sewage Disposal Works.

*Information from various towns. Compiled by G. T. Lynam, A.M. Inst. C.E., Burton-on-Trent. 1899.

Sewage (Purification of).

Information from 41 towns. Compiled by H. Richardson, A.M. Inst. C.E., Oldbury. 1890.

Sewers (Ventilation of).

Information from 81 towns. Compiled by J. T. Earnshaw, A.M. Inst. C.E., Ashton-under-Lyne. 1893.

Slaughter-Houses.

Information from 22 towns. Compiled by J. W. Cockrill, A.M. Inst. C.E., Great Yarmouth. 1885.

Tramways.

Information from 48 towns. Compiled by J. E. Swindlehurst, A.M. Inst. C.E., Burton-on-Trent. 1891.

Information from various towns. Compiled by the Town Clerk of Birmingham. 1899.

Tramways (Electric).

Information from 34 American and Canadian towns. Compiled by Chas. Mayne, A.M. Inst. C.E., Municipal Engineer, Shanghai. 1897.

Underground Telephone and Telegraph Wires.

*Information from various towns. Compiled by G. T. Lynam, A.M. Inst. C.E., Burton-on-Trent. 1899.

Water Rates.

Information from 25 (northern) towns. Compiled by A. W. Lawson, A.M. Inst. C.E., Borough Engineer, Rawtenstall. 1898.

Water Supply (Diameters and Depths of Mains Frozen in 1895).

Information from 55 towns. Compiled by E. Pritchard, M. Inst. C.E., Birmingham. 1895.

Water Supply (for Domestic and General Purposes).

Information from 111 towns. Compiled by J. T. Eayrs, A.M. Inst. C.E., West Bromwich. 1890.

Workmen's Dwellings.

*Information from 72 towns. Compiled by J. W. Cockrill, A.M. Inst. C.E., Great Yarmouth. 1897.

Workmen's Wages and Hours of Labour.

Information from various Metropolitan Public Bodies. Compiled by J. R. Dixon, A.M. Inst. C.E., Vestry Surveyor, St. Leonard, Shoreditch. 1897.

Information from 39 towns. Compiled by R. H. Haynes, Newport, Mon. 1897.

Information from various boroughs. Compiled by S. E. Burgess, M. Inst. C.E., South Shields. 1899.

Transactions of Other Societies, Books, Etc.

British Fire Prevention Committee.
Builder Student Series.
Clinical Research Association.
Engineering Association of New South Wales.
Field Work and Instruments. By A. T. Walmisley.

Land Surveying and Levelling. By A. T. Walmisley.
London Chamber of Commerce. Report on Cement Admixtures.
" " " " Secret Commissions.
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PAPERS.

A few prints of the following Papers (contained in past Volumes of 'Proceedings') are in stock at the Offices of the Association, and may be obtained from the Secretary, *if the* **Reference Number** *is quoted and an addressed postal wrapper is enclosed with application.*

1. **Address,** Mr. J. Gordon's Presidential.
2. **An English Municipal Engineer's Visit to America.** G. Livingstone.
4. **Bacterial Treatment of Sewage.** G. Thudichum.
3. **Barry Railway,** Description of the Rhymney Branch of. A. Pearce.
6. **Bute Docks,** Notes on. C. L. Hunter.
7. **Cable Traction,** Conversion of Edinburgh Horse Tramway System into. W. N. Colam.

43. **Portland Stone.** E. J. Elford.
44. **Power Houses,** On the abuse of. Sir W. H. Preece, K.C.B., F.R.S.
64. **Private Streets Works Act, 1892.** G. B. Laffan.
31. **Purification of Sewage by Land.** H. Royle.
35. **Rainfall,** Rate of. J. P. Dalton.
50. **Restoration of Municipal Buildings.** H. A. Cutler.
51. **Ripon,** Municipal Works in. W. Edson.
78. **Ripon,** Sewage Disposal Works. H. A. Johnson.
74. **Road Maintenance.** R. H. Dorman.
53. **St. George, Bristol,** New Public Park. T. L. Lewis.
54. **Sanitation,** Effect of Municipal Government on. H. P. Boulnois.
55. **Sanitary Legislation.** Prof. H. Robinson.
56. **Scarborough,** Public Works. J. Petch.
57. **Scarborough,** Waterworks. W. Millhouse.
58. **Seven years in a Black Country Town,** and Supplement. C. L. N. Wilson.
52. **Sewage Disposal by Artificial Filtration.** G. Reid.
38. **Sewage Pumping Machinery.** W. Fairley.
77. **Sewage Purification by Land.** H. Royle.
47. **Sewerage and Sewage Disposal Works.** J. Kemp.
60. **Sewer Ventilation.** J. Morgan.
62. **Specifications of Tyneside Roads.** H. W. Taylor.
63. **Stafford,** Municipal Works. W. Blackshaw.
48. **Staines Reservoirs Works.**
65. **Sunderland,** Electric Lighting. J. C. Snell.
49. **Tonbridge,** Municipal Work in. W. L. Bradley.
40. **Tramways in Asphalt.** L. H. Isaacs.
67. **Trade Effluents.** W. Spink.
68. **Use of Heat from Destructors.** A. H. Campbell.
69. **Ventilation of Sewers and Drains.** R. Read.
70. **West Cumberland,** Water Supplies. R. Pickering.
71. **Whitehaven,** Municipal Work. J. S. Brodie.
72. **Wimbledon,** Electric Lighting Scheme. A. H. Preece.
73. **Wimbledon,** Municipal Work. C. H. Cooper.
29. **Wood Pavements,** Jointing of. W. N. Blair.

VOLUNTARY EXAMINATIONS.

SYLLABUS.

The Incorporated Association of Municipal and County Engineers undertake the holding of Voluntary Pass Examinations for Candidates for Surveyorships under Municipal Corporations and the Local Government Acts.

Two or more Examinations are held in each year—in April and October. The April Examinations are held in London, the October Examinations in some provincial town to be fixed on by the Council and duly advertised beforehand.

The Examinations are by written papers and *vivâ voce*, upon the four following subjects:—

1st. Engineering as applied to Municipal Work.
2nd. Building Construction and Materials.
3rd. Sanitary Science as applied to Towns and Buildings.
4th. Municipal and Local Government Law as relating to the Work of Municipal Engineers and Surveyors.

Candidates are not necessarily required to answer all the questions set in each paper, though not less than four must be taken: marks are given for all questions correctly answered. The *vivâ voce* examination is held after the written papers are all sent in.

The Examinations occupy two days, and the arrangements are as follows:—

First day	..	10	to	1	..	Engineering.
„	..	2	„	4	..	Sanitary Science.
„	..	5	„	7	..	Municipal and Local Government Law.
Second day	..	9	„	11.30		Building Construction.
„	..	12	..		..	*Vivâ voce* Examination.

Fifty per cent. of the total number of marks given are required to constitute a pass.

Each candidate must fill up a Form of Application, to be returned in accordance with date given thereon.

Candidates must have attained their twenty-second birthday.

The fee for each Examination is *4l. 4s.*, two guineas to be paid on application, and the balance on the day of examination. Should the candidate fail, he is entitled to present himself at any subsequent

Examination, on payment of two guineas, one guinea to be paid on application and one guinea on the day of Examination.

Candidates who sat and failed at any of the Examinations held prior to and including April 1898, pay 1*l.* 1*s.* entrance and 10*s.* 6*d.* sitting fees.

No further charge is made to the candidate than the fees above mentioned.

Candidates who do not present themselves for Examination forfeit their entrance fee.

Successful candidates receive a Certificate in the form of a "Testamur," signed by the Examiners for the time being, and countersigned by the President and Secretary of the Association in Council.

No information as to the result of an examination, beyond the fact of a candidate having "Passed" or "Failed" is given.

Questions set at past Examinations can only be obtained in the Volumes of the 'Proceedings.' On Sale by Messrs. E. & F. N. Spon, Ltd., Publishers, 125 Strand, London, W.C.

Any inquiries referring to the examinations should be directed to Mr. Thomas Cole, Secretary to the Association, 11 Victoria Street, London, S.W., and should be accompanied by an addressed foolscap envelope.

SUBJECTS OF EXAMINATION.

I.—Engineering as applied to Municipal Work:

- A. Land Surveying and Levelling.
- B. Hydraulics.
- C. Sewerage and Sewage Disposal Works.
- D. Water Supply.
- E. Road Making.

II.—Building Construction: Strength of Materials:

- A. Materials.
- B. The Construction of Public and Private Buildings.
- C. Building Bye-laws.
- D. Public Baths and Hospitals.

III.—Sanitary Science as applied to Towns and Buildings:

- A. Ventilation of Buildings.
- B. Scavenging and Disposal of Refuse.
- C. House Drainage.
- D. Disinfection.

IV.—Municipal and Local Government Law as Relating to the Work of Municipal Engineers and Surveyors.

Note.—The Examiners do not recommend any particular text-books, as it is desired to make the Examinations rather a test of the candidate's practical knowledge of the subjects generally, than to find his acquaintance with any particular book or books.

EXAMPLES OF QUESTIONS.

The following are the Examination Papers set to the candidates at the Twenty-ninth Examination, held at the St. George's Hall, Liverpool, on October 6th and 7th, 1899, and serve as examples of questions asked under the different sections.

DIRECTIONS.—You are particularly requested to write legibly, and to answer the questions as concisely as possible. *Fill in your number where indicated, also at the top of every book handed in.* Prefix the number of the question to each answer. Wherever possible, freehand sketches or diagrams should be drawn to illustrate the answer; these should be carefully executed, as they will be taken as showing the candidate's proficiency in this style of drawing. Candidates must not, during the examination, refer to any books or manuscript, nor communicate with each other.

SUBJECT:—ENGINEERING AS APPLIED TO MUNICIPAL WORK.

Examiner: A. M. Fowler, M. Inst. C.E., F.S.I.

A. LAND SURVEYING AND LEVELLING.

1. Describe how you would fix up the theodolite when commencing to take angles in the field.
2. State by figures, and sketch how you would enter the readings in your book.
3. Describe the means you would adopt to test the accuracy of the spirit level before commencing work. State how you would proceed to adjust the line of collimation, giving sketch.
4. Give a short example of the manner in which you would keep your field book.

B. HYDRAULICS.

1. State the mechanism of the hydraulic ram, the hydraulic turbine, and "Shone's" ejector. Also state how they are worked and for what particular purposes they are, respectively, applicable.
2. State the quantity of water an iron pipe, 12 inches diameter, will discharge, laid on an undulating line a mile in length with a head of 200 feet. Give a formula showing the calculation, stating the hydraulic gradient.
3. State the maximum height to which water can flow out of a reservoir by means of a syphon. Give sketch.
4. Describe the mechanism as applied for working hydraulic cranes or lifts, i.e. the principal parts of construction.

C. Sewerage and Sewage Disposal Works.

1. State some of the methods adopted for ventilating sewers, and the prevention of an excessive flow of sewer air in the sewers to high levels.

2. State some of the methods adopted for flushing sewers. In case of structural works, give sketch.

3. State the several methods of treating sewage by the application of land. How the land should be prepared:—
   (a) Where the same is heavy.
   (b) Where of gravel formation, stating the number of persons per acre in each case respectively from which sewage could be applied.
   (c) Where sewage is treated by chemicals and subsidence in tanks what are the chemicals generally used?

4. State the quantity of mud—about—which can be precipitated from sewage at outfall works, say in tons per million gallons of sewage.
   (a) About what percentage of moisture does such mud contain before being pressed into cake, and after pressing?
   (b) To what extent is the mud reduced in bulk by pressing?

D. Water Supply.

1. What is the most economical pressure at which water should be supplied to a town, to guard against waste and repairs of fittings, &c.?

2. State a formula for calculating the pressure on the main, i.e. from a service reservoir, say at 200 feet above the delivery.

3. State how best to ascertain the yearly average of rain falling over a catchment area where the levels of the ground surface vary considerably.

4. State how a gauge should be fixed in a running stream, and how the depths of water running over the gauge should be ascertained.

E. Road Making.

1. Describe the best form of construction for macadam roads in rural districts, giving sketch of cross section showing superstructure with figured dimensions.

2. State how the metalling on the finished surface should be prepared and set, the material used for same where a steam roller is applied.

3. State some of the best methods of wood paving. The different qualities of wood. Describe the foundations generally adapted and materials used and methods for fixing.

4. What is tar macadam? How is the stone prepared before being placed in permanent position? How should the surface of the road be finished?

Subject:—Building Construction.

Examiner: T. H. Yabbicom, M. Inst. C.E.

A. Materials.

1. Describe the necessary qualities of good bricks, and how you would test their quality, without machinery, on the site of the works.
   (*a*) For front work;
   (*b*) For inside work.

2. Describe the defects in timber that should be guarded against when selected for constructive purposes, and how to detect in the timber yard the countries from which the stock has been imported.

3. One side of a roofing slate is smoother than the other; which side is laid uppermost? State reasons, and illustrate by sketch.

B. The Construction of Public and Private Buildings.

4. State the general principles to be kept in mind when designing a building for any public purpose.

5. Sketch an elevation of a timber queen-post roof truss of 35 feet clear span, suitable for a warehouse. Figure principal dimensions and show detail of joints.

6. When it is not possible to drain a house without laying the soil drain underneath the house, what materials would be preferably used for the construction of the drain?

C. Building Bye-Laws.

7. State the thickness of the external and party walls required by the Model Bye-Laws for the following buildings:—
   (*a*) A public building or warehouse, between 50 and 60 feet high, not exceeding 45 feet in length.
   (*b*) A domestic building 45 feet high, not exceeding 45 feet in length.

8. What provision is to be made for open spaces to domestic buildings when the depth of the site is so shallow that the prescribed area of 150 superficial feet in the rear cannot be obtained? Take the case of a building not exceeding 25 feet in height; illustrate by sketch.

D. Public Baths and Hospitals.

9. Draw a sketch section of a public swimming-bath 75 feet by 30 feet, water surface; figure the principal dimensions of walls, gangways, dressing-boxes, and sub-ways. Omit roof.

10. State the following points to be observed in designing a pavilion for hospital for infectious diseases:—

    (*a*) The distance of the beds from centre to centre;

    (*b*) The superficial floor space required for each patient; height of ward;

    (*c*) The number of cubic feet of air space allotted to each patient;

    (*d*) The proportion that the area of the window surface should bear to the cubic capacity of the ward;

    (*e*) In addition to the windows the provisions that should be made for efficient ventilation;

    (*f*) The best method of heating; thickness of outer walls.

SUBJECT:—SANITARY SCIENCE.

Examiner: Lewis Angell, M. Inst. C.E., F.R.I.B.A.

1. What are the component parts of pure air by weight and volume before inspiration? What change is found after expiration? In what manner does the atmosphere of an overcrowded and ill-ventilated room act on the physical system?

2. What cubic space per head should be provided for (*a*) ordinary living rooms; (*b*) for infectious hospitals?

3. Explain natural and artificial ventilation, describe a system of each and respective advantages; also methods of warming the external air before admission to a building.

4. Describe the arrangement and action of some one of the Dust-destructors. What temperature is usually maintained, what percentage of "clinker" remains? Explain the terms "forced draught," "baffle wall," and "fume cremator."

5. State the methods of disinfecting (*a*) rooms; (*d*) clothing and bedding. Define the terms "superheated" and "saturated" steam.

6. State the principles which should govern house drainage. Illustrate by detail sketches the section of a house having two w.-c.'s, one situate over the other; also a bath, scullery and slop sink. What is meant by "syphonage" in a soil pipe, how produced and how obviated?

7. In a main sewer, what are the relations between size, gradient and flow? What is meant by the terms "wetted perimeter" and "hydraulic mean depth," and how is the latter ascertained? Give a simple formula for determining the velocity of streams.

8. State the different theories with regard to the ventilation of sewers. If the presence of sewer gas is suspected in a house, what means would you adopt to detect it?

9. What is the proportion of liquid in precipitated sewage sludge, and what are the methods of disposal?

10. Describe the arrangements aud action of the bacterial system of sewage treatment, and state the distinction between aërobic and anaërobic bacteria.

Subject:—Municipal and Local Government Law, as Relating to the Work of Municipal Engineers and Surveyors.

Examiner: John T. Eayrs, M. Inst. C.E., F.S.I., &c.

1. (*a*) What are the conditions, subject to which Local Authorities shall afford facilities for manufacturers to discharge liquid refuse into sewers?

   (*b*) Define "pollution" as set out in the Rivers Pollution Prevention Act.

2. (*a*) State the objections which an owner of property may take to proposed private street works under the Private Street Works Act, 1892?

   (*b*) How are the objections determined?

   (*c*) What are the powers of the Court in relation thereto?

3. (*a*) What are the powers of a Local Authority under the Public Health Acts Amendment Act, 1890, with respect to means of ingress to and egress from places of public resort, and (*b*) what are included in "places of public resort" as defined by the Act?

4. Define (*a*) "official representation" and (*b*) "unhealthy area" under the Housing of the Working Classes Act, 1890, and (*c*) what may be excluded from or included in an Improvement Scheme under this Act.

5. (*a*) Under what conditions may a Local Authority construct Waterworks within the area of supply of an existing company?

   (*b*) What are the duties of a Waterworks Company under the Waterworks Clauses Act, 1847, in relation to—

   (1) A supply of water for cleansing sewers, drains, and for other purposes;

   (2) Fire-plugs and the fixing of such plugs;

   (3) Supply of water for extinguishing fires?

6. What powers have Local Authorities for the compulsory purchase of tramways belonging to a private owner or Company under the Tramways Act, 1870, when, and upon what terms or upon what basis can such purchase be made?

7. What proceedings are required to be taken and notices given before a Local Authority can (*a*) discontinue the maintenance of a public road which has become unnecessary, and (*b*) stop up or divert a public highway?

8. (*a*) Define "extraordinary traffic" in connection with highways?
   (*b*) What is the duty of the Surveyor in relation thereto?
   (*c*) Who is liable for any extra expense in maintaining roads in consequence thereof?
   (*d*) Cite any case which may have been decided on the subject.

9. Can a person make any alteration or addition to a building erected before the passing of the Public Health Acts without submitting plans to or obtaining the approval of the Local Authority, and would such person be liable to prosecution or penalties if the alterations or additions contravened any bye-law now in force?

The following are the Examination Papers set to the candidates at the Thirtieth Examination, held at the Examination Hall, London, on March 30th and 31st, 1900, and serve as examples of questions asked under the different sections.

Subject:—Engineering as applied to Municipal Work.

Examiner: Edward Pritchard, M. Inst. C.E., F.G.S.

Land Surveying and Levelling.

1. What is the area, in acres, of a triangular field two sides of which are 10 chains and 16 chains in length respectively, the contained angle being 30°?
2. When engaged in the field, your level is found to be out of adjustment, state what steps you would take to rectify it.

Hydraulics.

3. What is the discharge, in gallons per minute, through a right-angled triangular notch gauge, the height of water above the bottom of the notch being 3 inches?

4. What is the meaning of the words "Hydraulic mean depth" or "Hydraulic radius" applied to a waterway? What is the hydraulic mean depth of a 24-inch circular sewer with 6 inches depth of water running in it?

SEWERAGE.

5. State what you know of the bacteriological treatment of sewage.

6. What size of outfall sewer would you design for a non-manufacturing town with a population of 18,000, the outfall works being situated at a distance of one mile from the town, the available fall being 5 feet, the rainfall as far as possible to be excluded?

7. What is considered a self-cleansing velocity in small circular sewers? What gradient would be necessary to give this velocity in the case of a 12-inch diameter pipe running half full and full respectively?

8. Give a sketch section of a Scott-Moncrieff installation for the purification of sewage. What is the chief feature of this system?

WATER SUPPLY.

9. A pumping engine is required to deliver 100 cubic feet of water per minute through a pipe three miles long, to a head of 100 feet above the source of supply, the diameter of pipe being 10 inches. Find the I.H.P. of the pumping engine; the efficiency of machinery being 0·66.

10. Give a sketch section of an embankment or an open catch-water storage reservoir, showing puddle wall, &c.

ROAD MAKING.

11. Sketch a cross section of a 50-feet macadamised roadway, including paved footpaths, showing cross fall, &c.; give a brief description of the material to be used.

12. Enumerate the principal methods of street pavement, stating under what conditions each is most suitable.

SUBJECT:—BUILDING CONSTRUCTION.

Examiner: James Lemon, M. Inst. C.E., F.R.I.B.A.

1. Draw a section of the front wall to a warehouse, in accordance with the Model Bye-laws, 48 feet in height, showing the concrete foundation, footings, sets-off to wall, and cornice, the length of the building being 40 feet.

2. Draw an elevation of a framed partition 20 feet long and 10 feet high, with a doorway at one end, giving the dimensions of all the timbers.

3. Draw an elevation of a queen post principal for a span of 40 feet, giving dimensions of all timbers, including purlins with 10 feet bearing, common rafters, ridge, plates, &c.
4. What is the tensile strain on the bottom flange of a girder at a point 7 feet from one end, the load being 12 tons, the depth of girder 18 inches, and the length between supports 20 feet ?
5. Draw a wrought-iron roof principal for a 40-feet span in lines only, but show cross sections in figured dimensions of the various parts of the truss, including the details of the connections on a large scale.
6. Write a specification of plumber's work for lead flats, gutters, valleys, and flashings, and give the weight of lead and mode of construction you advise.
7. Give illustrations of the various modes of fireproof construction, and state their advantages and disadvantages.
8. Write a specification for a ward in an infectious diseases hospital.

SUBJECT :—SANITARY SCIENCE.

Examiner :—A. M. Fowler, M. Inst. C.E., F.S.I.

1.—VENTILATION.

(*a*) State some of the best known methods of heating public schools having several rooms.

(*b*) How can fresh air be supplied, and how can foul air be extracted ? State some of the known methods, and for laboratories.

(*c*) What quantity of moisture should wholesome air contain in proportion to saturation ?

(*d*) How can moisture be supplied where rooms are heated by heating apparatuses ?

2.—SCAVENGING.

(*a*) What are the principal features to be secured in the construction of a refuse-destructor in addition to cremation ? Give sketch showing general arrangement.

3.—HOUSE DRAINAGE.

(*a*) State some of the best known methods for flushing house drains.

(*b*) What is the minimum inclination to which house drains should be laid ?

4.—DISINFECTION.

(*a*) Name the disinfectants which are generally used in connection with house and hospital drains.

(*b*) State some of the known methods adopted to guard against contagion spreading to rooms in dwelling-houses.

Subject :—Municipal and Local Government Law, as Relating to the Work of Municipal Engineers and Surveyors.

Examiner :—John T. Eayrs, M. Inst. C.E.

1. State the provisions of the Towns Improvement Clauses Act 1847? as to
   (*a*) Removal of *existing* projections of houses.
   (*b*) Removal of *future* projections of houses.
   (*c*) What are included in the term "projections."
   (*d*) Affixing of waterspouts to buildings.

2. What are the general provisions of the Quarry (Fencing) Act, 1887; give the definition of "Quarry," and under what Act and Clauses must proceedings be taken for an offence under this Act?

3. Can the water authority for a district, whether a company or Local Authority, lay water mains in a street which is not repairable by the inhabitants at large, without the consent of the owners of such street?

4. Under what statutes is provision made for
   (*a*) The erection and maintenance of boundary posts and direction posts, and
   (*b*) Where the centre of a highway forms the boundary of two parishes or districts, how is the question of repairs to be settled and what circumstances shall be taken into consideration, and by whom, in determining the proportions to be repaired by each district respectively?

5. What are the provisions in the Highway Act, 1835, as to obtaining materials for the repair of highways from commons, rivers, sea-beach, enclosed lands; also as to the fencing and filling up of gravel pits from which material may be obtained?

6. What powers have Local Authorities for the prevention of danger to the public from telegraph, telephone, or other wires placed over any street? State generally the extent of such powers, and the exemptions from their operation.

7. What is the nature of the legal proceedings which may be taken for an offence under the Rivers Pollution Prevention Act, 1876? What facts must be proved before a conviction can be secured? And under what circumstances can anyone discharge noxious or polluting solid or liquid matter into a stream without having committed an offence under the Act?

8. Under what powers can a Local Authority construct a new sewer and charge the owners of the property to be benefited by such sewer with the cost? (*Note—This question does not refer to the construction of sewers in private streets.*)

The following are the Examination Papers set to the candidates at the Thirty-First Examination, held at the Medical Hall, London, on April 6th and 7th, 1899, and serve as examples of questions asked under the different sections.

SUBJECT: ENGINEERING AS APPLIED TO MUNICIPAL WORK.

Examiner: W. Santo Crimp, M. Inst. C.E., M.S.I.

1. A wood is to be surveyed with a theodolite and chain. Describe the *modus operandi*, and illustrate the answer with sketches.
2. Describe the manner of adjusting a level by means of a pond.
3. Give an ordinary page of a levelling book, with the readings worked out.
4. State what you know of the formulas used for pipe discharges and for weir gaugings.
5. Describe how you would make a sewer 12 inches in diameter in wet ground, the depth being 12 feet.
6. Give sketches of a junction man-hole, and of a lamp-hole.
7. State the general principles with regard to sewer flushing, and describe appliances used.
8. State the usual capacities of settling tanks, and describe the difference of action between open and closed septic tanks.
9. State the maximum quantity of sewage, in gallons, that the best land will purify per acre per day. Clarified sewage is referred to.
10. State the present requirements of the Local Government Board with regard to bacterial filters.
11. Describe the proper way of laying and jointing a 4-inch service main, and state the proper amount of cover required to prevent freezing.
12. Give the cross sections of a road, to be of a width of 40 feet, for suburban traffic, the subsoil being of clay.
13. State the best ways of laying the different classes of pavements, with sketches.
14. What is the general effect of watering roads, and how many times per diem should roads in urban and rural districts be watered? What is the average quantity of water used per square yard at each watering?
15. What is the best weight, per foot of width, for steam road rollers? How many square yards per diem will a 10-ton roller solidify?

Subject :—Building Construction.

Examiner : Francis J. C. May, M. Inst. C.E., F.S.I.

1. What is the difference between single and double laths, and of what does the first coat of plaster on ceilings ordinarily consist?

2. Explain by sketches the meaning of the following terms: "fascia and soffit boarding to eaves," "flitched girder," and "torus moulded skirting."

3. What are the principal defects to be looked for in selecting timber in balk? Describe them as far as possible by means of sketches.

4. In a terrace of houses the closets and bathrooms are at the back, and the drains have to pass through, under the basements, to the sewer which runs along the road in front. Show by sketches how you would render the houses safe against sewer gases.

5. Explain the meaning of "hydraulic lime," and how you would test a specimen of limestone in order to ascertain whether it would produce a hydraulic lime.

6. Explain the meaning of the following terms in plasterer's work: Counter-lathing, Screeds, Rendering, Putty, Gauged stuff.

7. An iron roof truss over a 24-feet span consists of tee-iron principals 3 inches by $2\frac{1}{2}$ inches by $\frac{3}{8}$ inch, two angle-iron struts $1\frac{1}{2}$ inches by $1\frac{1}{2}$ inches by $\frac{3}{8}$ inch, and five tension rods of $\frac{7}{8}$ inch diameter. Draw the elevation of about half the truss, to a scale of two feet to an inch.

8. Draw a cross section, to a scale of 1 inch to a foot, through an 8-inch lead gutter with step flashings, formed at the end of a boarded and slated roof butting against the brick wall of another building. Also show the step-flashings in elevation.

9. How should cut stonework in dressings and cornices be laid in order to guard against disintegration, and to what class of rocks does this rule apply with the greatest force?

10. Give a vertical and a horizontal section to a scale of 2 inches to a foot, showing all the details, of a sliding sash window in a 9-inch brick wall. Size of opening 3 feet by 3 feet 6 inches high.

11. Give line diagrams showing the iron roof trusses you would use for a 20-foot and 40-foot span. Show the sections you would adopt for the different members, and give detail sketches of all the principal joints of the 40-foot truss.

12. Draw to a scale one-third full size, a rolled iron joist 10 inches by $4\frac{1}{2}$ inches, the web being $\frac{3}{8}$ inch, and the flanges averaging $\frac{1}{2}$ inch.

Subject :—Sanitary Science.

Examiner : Joseph Lobley, M. Inst. C.E.

1. State the difference in methods of ventilation: (*a*) position of air-inlets, (*b*) temperature of air to be admitted compared with outside air, and how the difference would be effected in winter or summer, (*c*) method of extraction, (*d*) what is meant by the "plenum system."

2. What amount of fresh air in cubic feet should be admitted per hour into (*a*) sitting-room with four persons and three gas-burners, and open fireplace, (*b*) large hall or concert room with 2000 persons seated therein, (*c*) accident ward (ten beds) of a hospital. Describe in each case how you would arrange for the air to be admitted, and how draughts may be minimised.

3. What precautions are neccssary to secure a pure supply of water from a well?

4. What kind of water is most likely to dissolve lead and to carry the same to the consumer?

5. Describe a common house filter and criticise same. What is the chemical action? Describe Pasteur-Chamberlain filter.

6. How would you fix a rain gauge?

7. Describe shortly a bacteria filter for sewage purification, and explain the difference between it and sewage irrigation on suitable land. Describe in each case the chemical, mechanical and biological action of the operation.

8. What amount of sewage per day may be safely passed on to each acre of good land laid out as an irrigation farm, and what amount on to each square yard of bacteria filter?

9. Where and under what conditions would you consider a slop water closet suitable?

10. Describe the construction of a good dust or ash pit. How is house refuse best dealt with at the dwellings?

11. What effect has a damp subsoil upon the health of a locality?

12. Explain what you would consider the best form of water closet, and why? —and what in your opinion is the worst form likely to be found fitted?

SUBJECT:—MUNICIPAL AND LOCAL GOVERNMENT LAW AS RELATING TO THE WORK OF MUNICIPAL ENGINEERS AND SURVEYORS.

Examiner:—Charles Jones, M. Inst. C.E.

Give the date and title of Act of Parliament under which bye-laws requiring notice of "Alterations" to buildings are framed.

Give the general purport of the above Act.

State title of Act, and specify details of provisions for secondary means of access, for removal of house refuse.

Specify particulars, from 1890 Act, with respect to the removal of "Offensive matter"—its mode of removal, and any sanitary provisions made for the protection of the public.

Under what particular Act or Acts does an Urban Authority deal with: (*a*) Public Bathing? (*b*) Horses, Pleasure Boats, &c.? (*c*) Pleasure Grounds? (*d*) Shooting Galleries, Swings, &c.? (*e*) Hackney Carriages?

HOUSING OF THE WORKING CLASSES ACT.

Give definitions from the above Act, of (*a*) the word "*Street*," (*b*) the word "*Dwelling-house*," (*c*) the word "*Owner*," (*d*) the words "*Closing Order*."

PUBLIC HEALTH ACT, 1875.

Give section and general power vested in authorities under the above Act, authorising a proper supply of water for domestic purposes.

Under what powers may improvements, such as setting back projecting fronts, &c., in a line of street be made?

Give details of above.

BOARD OF EXAMINERS.

Chas. H. Lowe, M. Inst. C.E. (*President*).

The President of the Association (*ex-officio*).

Lewis Angell, M. Inst. C.E., F.R.I.B.A., Fellow of King's College, London, Stanley House, Romford Road, Forest Gate, E. (Past President).

J. P. Barber, M. Inst. C.E., Vestry Surveyor, St. Mary's, Islington (Member of Council).

W. Nisbet Blair, M. Inst. C.E., Vestry Surveyor, St. Pancras (Member of Council).

J. C. Bretland, M. Inst. C.E., City Surveyor, Belfast.

A. E. Collins, M. Inst. C.E., City Engineer, Norwich (Member of Council).

W. Santo Crimp, M. Inst. C.E., F.G.S., M.S.I., 27 Great George Street, S.W.

H. A. Cutler, A. M. Inst. C.E., City Engineer, Cork.

R. H. Dorman, M. Inst. C.E., County Surveyor, Armagh.

J. T. Eayrs, M. Inst. C.E., F.S.I., 39 Corporation Street, Birmingham (Past President).

A. M. Fowler, M. Inst. C.E., F.S.I., 1 St. Peter's Square, Manchester (Past President).

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S. Harty, M. Inst. C.E. I., City Engineer, Dublin.

C. Jones, M. Inst. C.E., Surveyor to the Urban District Council, Ealing, W. (Past President).

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J. Price, M. Inst. C.E., City Engineer, Birmingham (Member of Council).

W. Weaver, M. Inst. C.E., Vestry Surveyor, Kensington (Member of Council).

T. H. Yabbicom, M. Inst. C.E., City Engineer, Bristol (Vice-President).

CANDIDATES WHO HAVE PASSED THE EXAMINATIONS HELD 1899–1900.

29th Examination, October 1899.

C. F. Dawson.
H. Goodfellow.
C. Hall.
J. W. Harrison.
W. Henry.
E. R. Hinchsliff.
C. Johnston.
D. E. Lloyd-Davies.
D. Ross.
R. Simmons.
F. J. Slater.
J. A. Spreckley.
A. S. Wootton.

30th Examination, March 1900.

E. H. Crump.
J. Eastwood.
G. Jerram.
W. C. Holloway.
K. G. MacDonald.
W. L. F. Palmer.
W. Percival.
E. S. Perrott.
F. Read.
W. Ridler.
F. M. Royle.
H. Tompkins.
H. Tremelling.
J. Watmore.
W. P. Wrack.

31st Examination, April 1900.

A. H. Bevan.
C. A. Coombs.
J. E. Fothergill.
J. Gair.
E. Hobson.
A. B. Lismer.
F. W. Mager.
H. Mattinson.
R. B. Phillips.
A. J. Rousell.
W. Shackleton.
E. W. Swinstead.
H. V. Towner.
W. R. Warlow.
B. J. Wolfenden.
W. E. Woollam.

Memoirs of Deceased Members.

The Council having been requested to append some short notice of the decease of Members of this Association, will feel obliged by early notice being forwarded to the Secretary, with such particulars as it may be desirable to insert in these 'Proceedings.'

EDWARD PRITCHARD was born at Wrexham on the 13th September, 1838. His early professional life was spent in survey and railway work in this country and in Australia. In 1865 he became Borough Surveyor of Clitheroe, and held that post until June 1870, when he was appointed Borough Surveyor to the Corporation of Warwick. There he induced the Corporation to adopt his scheme for a sewage farm, and at the same time a joint Drainage Committee for the districts draining into the river Tame was formed. He also took in hand the provision of a water supply for Warwick, and his scheme, by which the water was brought by gravitation from Haseley Brook, near Haseley Mill, was successfully carried out. The Warwick and Leamington Tramway was also laid down by Mr. Pritchard. At Clitheroe and at Leigh, he had organised volunteer fire brigades, of which he acted as captain. Soon after he took up his residence at Warwick he became lieutenant of the Volunteer Fire Brigade there, and in that capacity was present at the great fire at Warwick Castle in December 1871.

In 1876 Mr. Pritchard resigned his appointment at Warwick and commenced independent practice, with offices in Birmingham and in London. Over a hundred towns in Great Britain have been provided by him with waterworks, sewerage or tramways. The Wolverhampton Corporation was one of the many public bodies which sought his assistance in the matter of sewage disposal. In August 1888, he went to South Africa, to report for the municipality of Cape Town, on the best means of sewering the district and disposing of its sewage. This led to his being retained by the municipalities of Woodstock, Claremont and Wynberg, important districts closely adjoining Cape Town. While waiting for surveys to be completed at Cape Town he visited the diamond

fields of Kimberley, and the goldfields of the Transvaal. At Kimberley he was able to give some important advice to the authorities on the question of sewage disposal, and at Johannesburg, then just rising into importance, he received instructions to prepare a scheme which should supply water for gold-washing at the mines, as well as for domestic purposes in the town. The waterworks which supply the town of Pretoria were designed by him, and the fittings were sent from this country under his supervision. A water company at Klerksdorp also carried out under his advice a scheme for supplying the town from a point in the Vaal river, eight miles distant.

As a tramway engineer, Mr. Pritchard was associated with many notable undertakings. One of the earliest of those enterprises was that at Magdeburg. In 1886, when he was acting as Engineer to the then Birmingham Central Tramways Company, he took part, with Mr. Joseph Kincaid, in designing and carrying out the cable tramway. He prepared himself for the work by making exhaustive inquiries in the United States into the various systems of working cable tramways there, and came back thoroughly convinced that this was the most economical form of street locomotion which had then been put into practice. He recommended its adoption both on the Handsworth route and on the Bristol Road, the control of these routes having just been taken over by the Central Company from the old Birmingham Tramway and Omnibus Company. The Handsworth line was reconstructed on the cable system, and it is largely due to the care and skill exercised by Mr. Pritchard that the work was carried out in such a way that the Handsworth tramway service is still the most efficient and profitable in the city and neighbourhood. Among other tramway systems carried out by Mr. Pritchard are those at Leamington and Warwick, Barrow, Dudley and Stourbridge.

Some years back, Mr. Pritchard was engaged in the development of gold mines in Silesia under the Austro-Hungarian Government. In 1896 he was retained by a syndicate for exploitation of the then newly-opened goldfields of British Columbia. He spent some time there prospecting on behalf of the company, and took advantage of his visit to make some observations on the tramways of the Canadian cities.

He was a Fellow of the Geological Society, a Member of the Royal Meteorological Society, a Member of Council of the Sanitary Institute of Great Britain, and a Member of the North of England

Institute of Mining and Mechanical Engineers. He was also a prominent Freemason. Mr. Pritchard was married to a daughter of the late Lieut.-Colonel John Stenson, of the 1st Dragoon Guards, who survives him. He died at his residence, Park Mount, Selly Oak, Birmingham, on the 11th May, 1900. (Excerpt Min. Proc. Inst. C.E., vol. cxli. 1900.)

Mr. Pritchard was one of the Founders of the Association. He was for many years Honorary Secretary of the Midland District, and rendered valuable assistance as an Examiner from the institution of the Examinations.

THOMAS NUTTALL, born at Bury on the 20th February, 1838, was educated at the Grammar School in that town. In 1854 he was articled for five years to Messrs. Gorton and Cross, of Bury, mining engineers and surveyors, in whose employment he subsequently remained. In 1863 he commenced business on his own account in Broad Street, Bury. Among the works on which Mr. Nuttall was employed may be mentioned the surveys for the Sheffield, Buxton and Liverpool Railways, the Lancashire Union Railways, for the waterworks at Stockport, Sheffield, Sunderland, Nottingham, Wakefield, Derby, Newcastle and Gateshead, Matlock and Newark, and for Moston Colliery, North Wales. He acted as Land Stewart for the Trustees of Bury Grammar School, and as Surveyor to the District Councils of Kearsley, Ramsbottom and Prestwich. He had considerable practice in Lancashire in arbitration cases and as a Parliamentary Surveyor. Mr. Nuttall was a Fellow of the Surveyors' Institution, a Member of the Incorporated Association of Municipal and County Engineers, and in 1889 President of the Manchester District Society of Surveyors, Land Agents and Valuers. He died at his residence, Fernsholme, Bury, on the 6th May, 1900. (Excerpt Min. Proc. Inst. C.E., vol. cxli. 1900.)

Mr. Nuttall was elected a Member of this Association in July 1887.

THOMAS CHARLES THORBURN, late Borough Surveyor, Birkenhead, died on the 7th of April, 1900, at the age of 76. After nine years' employment on the Ordnance Survey, Mr. Thorburn was appointed, in 1854, as Surveyor to the Derby Local Board, and subsequently Borough Surveyor and Engineer, which position he held for about ten years. He was appointed town and building